8 ERROR 28 36 44 50 70
77 ADDRESSES

November 1995
£ 2·45

ELEKTOR ELECTRONICS

THE INTERNATIONAL ELECTRONICS MAGAZINE

Focus on: Scope multimeters

AUDIO & HI-FI • COMPUTERS & MICROPROCESSORS • DESIGN IDEAS • RADIO, TELEVISION & COMMUNICATIONS • SCIENCE & TECHNOLOGY • TEST & MEASUREMENT

OSCILLOSCOPE PRESCALER

FM noise squelch

300 watt power amplifier

Jogging LED

11

9 770268 451043

ELEKTOR ELECTRONICS

CONTENTS

November 1995
Volume 21
Number 238
ISSN 0268/4519

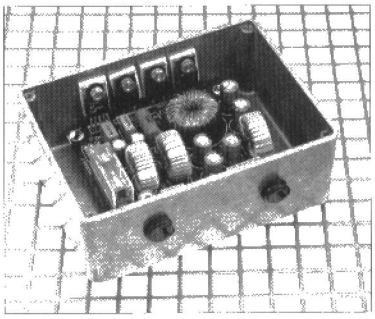
In next month's (our 21st anniversary) bumper issue:

- 50+ small projects
- Focus on: soldering
- Programmable Logic Controller
- Guitar Amplifier
- Smart Transistor Tester
- Fax Receiver for VLF and SW
- and others for your continued interest

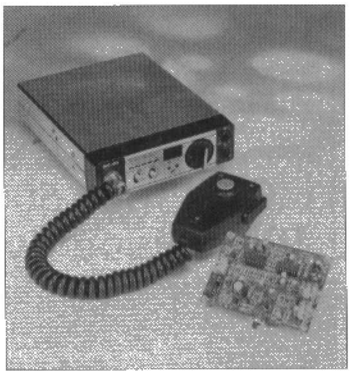
We regret that owing to circumstances beyond our control, the articles 'Surround sound boxes' and 'Small power supply' had to be carried over to the December issue. The article 'Simple switching unit' was renamed 'National Semiconductor's LM2575 as voltage inverter'

Front cover
A frustrating difficulty with analogue oscilloscopes is that the test time per scale division is relatively short when slow processes are being measured. The prescaler shown in the photograph enables the time base of the oscilloscope to be set between 1 second and 30 hours.

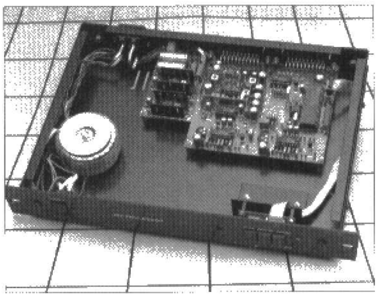
The winner of the international 1st prize in our design competition will be announced in our December 1995 issue



Symmetrical supply in cars – p. 10



FM noise squelch – p. 18



Picture-in-picture processor – p. 50

Scope multimeters – p. 74

Elektor Electronics is published monthly, except in August, by Elektor Electronics (Publishing), P.O. Box 1414, Dorchester, Dorset DT2 8YH, England. The magazine is available from newsagents, bookshops, and electronics retail outlets, or on subscription at an annual (1996) post paid price of £30·00 in the United Kingdom; air speeded: £38·00 in Europe, £47·00 in Africa, the Middle East and South America; £49·00 in Australia, New Zealand and the Far East; and $US 64.00 in the USA and Canada. Second Class Postage paid at Rahway N.J.
Postmaster: please send address corrections to Elektor Electronics, c/o Mercury Airfreight International Inc, 2323 Randolph Avenue, Avenel, New Jersey, N.J. 07001.

FROM THE WORLD OF ELECTRONICS

The Move to Broadband End-to-End

The ISDN (Integrated Services Digital Network) is being rolled out in many countries around the world and is attracting a growing number of users. However, at the same time, there is an increasing view that it will be unable to provide the functionality that business will need in the not too distant future. A wide consensus is that asynchronous transfer mode (ATM) technology will be needed because it has the potential to support applications ranging from the bandwidth-hungry CAD (computer aided design) and high-quality video through to simple voice communications.

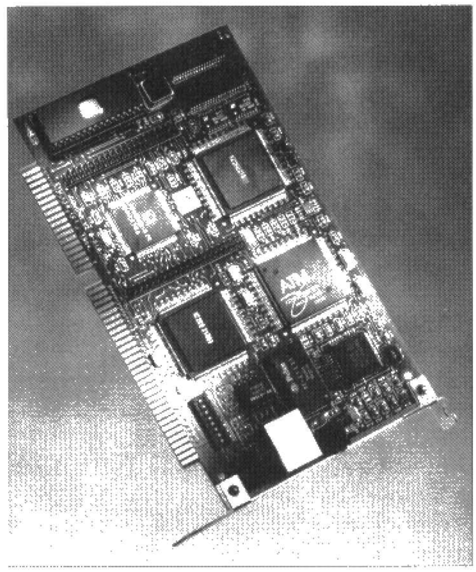
Recent developments in Britain – BT Laboratories (BTL) in transmission and Advanced Telecommunications Modules Ltd (ATML) in ATM technology – are likely to have an important role to play. Consequently, even though wide-area ATM from desk-to-desk is not yet here, these two elements will bring it a lot nearer.

N-ISDN (narrow-band ISDN), which is really what w should now call ISDN, is suitable for a wide range of applications and is a great improvement on the analogue networks that have been in service for many years even though it only provides 64 kbit/s channels. Yet, while the core networks are increasingly employing optical fibre as the transmission medium, the copper 'local loop' from the local telephone exchange to the subscriber is a bottleneck and is a missing link in effective end-to-end broadband communications.

The cost of telecommunications-quality semiconductor laser diodes is inherently expensive, at about £ 100 (£ 160) each, because of the time-consuming process of aligning the laser and fibre pigtail, which requires a skilled operator and expensive computer-controlled equipment. The result is that they are not economically viable in the local loop for delivering fibre-to-the-home (FTTH). Thus, they are not used in large quantities and manufacturers cannot obtain the economies of scale necessary to bring down prices.

Cutting costs

However, BTL has developed a technology which overcomes the problem of alignment between laser and fibre pigtail and so obviates the time-consuming and highly expensive stages in manufacture. This will cut the cost of the lasers, and so will speed the introduction of FTTH. Given the large potential market, the cost of these lasers could well fall to around £ 10 – a reduction by a factor of ten.



ATM25 plug-in card for PC (ATML).

The technology will cut costs by allowing crude, and therefore low-cost, automated pick-and-place assembly to be used and yet still result in the same proportion of light (over 50%) to be coupled into the fibre.

The requirement is to align two very small objects very precisely. Semiconductor lasers have an optimum active cross-sectional area that is typically 1–5 μm wide by 0.15 μm thick. This results in the light guided by the device having a spot size of about 1×0.75 μm, where this spot size is defined as the point at which the light intensity falls to about half the value relative to the centre.

This optimum active dimension is determined by both the refractive indexes of the semiconductor materials used and the need to obtain high electrical current densities within the active region, while maintaining a low operational current. The larger mode size, of about 9 μm diameter of a single mode optical fibre, is determined by its lower refractive index.

Limited distance

Only about 10% of the light from the fibre would be coupled to a cleaved optical fibre because of this modal mismatch. This poor coupling efficiency limits the distance over which the optical signal can be transmitted without the need for amplification or regeneration.

Traditionally, this problem has been overcome by placing a lens between the laser and the fibre with, in many cases, the lens being formed on the end of the fibre itself. Use of a lens typically boosts the coupling efficiency to around 50% and so allowing the the transmission distance to be increased by up to 25 km (15 miles). The penalty for using a lens is that the positioning of the fibre relative to the laser becomes more critical. A lateral movement of only 1.2 μm will reduce the amount of light coupled by half.

The BTL development involved a number of elements which, together, resulted in a major breakthrough. The first was the development of a laser that incorporates a taper to increase the mode size of the laser to match more closely that of the fibre. This removes the need for expensive lens-ended fibre and yet allows light from the laser to be coupled directly to a cleaved optical fibre with efficiencies of up to 75%. More importantly, this also increases the alignment tolerance of the laser by a factor of three.

Precision cleaving

The second element was the development of a precision cleaving technique that allows the position of the laser active region relative to the edge of the chip to be known far more accurately than when the traditional cleaving technique using a diamond-tipped scribber is used.

Finally, there was the development of the micro-machined silicon mount on which the laser sits. This incorporates a silica stop to which the laser is aligned just by pushing it until contact is made and a precision-etched V-groove in which the fibre may be glued.

Not only does the combination of these three elements enable the BTL researchers to obtain coupling efficiencies of over 50% by purely passive alignment, but the outcome is a technology which is suitable for high-volume production. This will deliver FTTH (or to the small office).

The next requirement is to deliver ATM to the desk with the ATM25 (25.6 Mbit/s) specification, which is aimed at meeting (and going beyond) all current broadband desk-top requirements, and which operates over the standard voice-grade 10BaseT (UTP-3) wiring. Hence, it will enable users to migrate readily from Ethernet to a higher performance network at an average price of around £ 500 (£ 800) per port – a figure comparable with switched Ethernet.

Affordable solution

With this market in mind, British company ATML has launched a range

of products aimed at providing an affordable ATM solution to fit seamlessly into PC workgroup computing. Products are already operating in test applications as diverse as an interactive cable TV trial in Cambridge, where they are supporting delivery of on-demand services to over 200 homes and at Olivetti Research Labs, where workgroup video-mail and videoconferencing is used extensively.

In many instances, users will migrate from their existing systems piecemeal rather than all at once. Hence, they need ease of use with features such as plug-and-play installation to minimize the problems in adding individual end-users. To buffer against unusual traffic conditions, the system can incorporate a separate memory bank in addition to Fi-Fo (first-in, first-out) stores.

On the applications side, ATML offers a high-performance disc storage RAID array optimized for multimedia applications in a PC workgroup environment. It simultanously supports multiple audio and video streams for multiple PC clients. Offering up to 16 Gbyte of storage, it provides high bit-rate media streams on an ATM network and is ideal for applications such as training, video-mail, and video-on-demand which require video playback.

These are two links in the chain needed to provided end-to-end connectivity for users who range from the large corporation to the SoHo (small office/home office) worker. The result is that organizations should consider ATM in their long-term strategies for the future.

BT Development & Procurement, BT Laboratories, Martlesham Heath, Ipswich, United Kingdom IP5 7RE. Phone +44 (0)1473 647 448. Fax +44 (0)1473 637 626.
Advanced Telecommunications Modules, Mount Pleasant House, 2 Mount Pleasant, Huntingdon Road, Cambridge, United Kingdom CB3 0BL. Phone +44 (0)1223 566 919. Fax +44 (0)1223 566 915.

Consumer Electronics Trends in the mid-1990s

"This has been the best sales year in the four-decade history of colour televisions," said Gary J. Shapiro, group vice president of the Electronic Industries Association's Consumer Electronics Group (EIA/CEG), as 1994 drew to a close. "What we're seeing is a convergence of at least three factors: a stronger US economy, renewed consumer confidence, and a desire on the part of consumers to upgrade their video and audio systems." What Mr Shapiro said of colour televisions, historically the premier US consumer electronics product, is generally true of consumer electronics as a whole. Record-setting sales in 1994 are being followed by rising sales levels in many consumer electronic product categories this year.

EIA's huge International Winter Consumer Electronics Show® in Las Vegas, Nevada, USA every January is always a reliable indicator of current American trends, and trends in the United States have traditionally foreshadowed industry developments in other parts of the world. CES® attracts more than 100,000 industry attendees, including retailers, distributors, industry analysts and media from over 100 countries.

Including all consumer product categories, Winter CES offers more than 100,000 square metres of exhibit areas that represent the world's largest gathering of mobile electronics products, home office, electronic gaming hardware and software, home automation, and home theatre products, in addition to the traditional audio and video categories. The largest trade-only show in the United States, Winter CES also features dozens of workshop sessions and seminars about the state-of-the-art in consumer electronics technology and merchandising. Ninety-five of the US industry's top 100 retailers participated in the 1995 show, as did 24 of the top 25 personal computer retailers. Almost 14,000 visitors from 103 other countries made up 13% of the total attendance. Taken together, Winter CES participants create a kind of 'snapshot' of trends in US consumer electronics in the mid-1990s and forecast the waves that will be breaking on other shores over the next few years.

Home office/mobile office

Pressured by the massive restructuring of many American corporations, millions of workers, including former executives, have chosen to start their own home-based businesses. According to BIS Strategic Decisions, a market research firm, when you count people who have set up home offices

Produced and published by **ELEKTOR ELECTRONICS (Publishing)**

Editor: Len Seymour
Technical Editor: Jan Buiting

Editorial & Administrative Offices:
P.O. Box 1414
DORCHESTER DT2 8YH
England
Telephone: (01305) 250995 (*National*)
or +44 1305 250 995 (*International*)
Fax: (01305) 250 996 (*National*)
or +44 1305 250 996 (*International*)

U.K. Advertising Office:
3 Crescent Terrace
CHELTENHAM GL50 3PE
Telephone: (01242) 510 760
Fax: (01242) 226 626

International Advertising Office:
Elektuur BV
P.O. Box 75
6190 AB BEEK
The Netherlands
Telephone: +31 46 4389 444
Fax: +31 46 437 0161

Subscriptions:
World Wide Subscription Service Ltd.
Unit 4, Gibbs Reed Farm
Pashley Road
TICEHURST TN5 7HE
Telephone: (01580) 200 657 (*National*)
or +44 1580 200 657 (*International*)
Fax: (01580) 200 616 (*National*)
or +44 1580 200 616 (*International*)

Head Office:
P.O. Box 75
6190 AB BEEK
The Netherlands
Telephone: +31 46 438 9444
Fax: +31 46 437 0161
Managing Director:
Johan H. Boermann
Deputy Managing Director:
Menno M.J. Landman
Editor-in-Chief/Publisher:
Pierre E.L. Kersemakers

Distribution:
SEYMOUR
1270 London Road
LONDON SW16 4DH

Printed in the Netherlands by NDB, Zoeterwoude

Overseas editions:
FRANCE
Elektor sarl
Les Trois Tilleuls
B.P. 59; 59850 NIEPPE
Editor: G.C.P. Raedersdorf

GERMANY
Elektor Verlag GmbH
Süsterfeldstr. 25
52072 AACHEN
Editor: E.J.A. Krempelsauer

GREECE
Elektor EPE
Karaiskaki 14
16673 Voula—ATHENA
Editor: E. Xanthoulis

INDIA
Elektor Electronics PVT Ltd
Chhotani Building
52C, Proctor Road, Grant Road (E)
BOMBAY 400 007
Editor: C.R. Chandarana

ISRAEL
Elektorcal
P O Box 41096
TEL AVIV 61410
Publisher: M. Avraham

NETHERLANDS
Elektuur BV
Peter Treckpoelstraat 2–4
6191 VK BEEK
Editor: P.H.M. Baggen

POLAND
Elektor Elektronik
02-777 Warszawa 130
Skrytka Pocztowa 271
Editor: W. Marciniak

PORTUGAL
Ferreira & Bento Lda.
Campo Grande, 56 – 8°/9°
1700 LISBOA
Editor: F. Ferreira de Almeida

SPAIN
Resistor Electronica Aplicada SA
P. de la Castellana, 212–4° Izda
28046 MADRID
Editor: Agustin Gonzales Buelta

SWEDEN
Electronic Press AB
Box 5505
14105 HUDDINGE
Editor: Bill Cedrum

to supplement their incomes, handle take-home work from their corporate offices, or telecommute via computer a couple of days a week, the total number of home offices exceeds 40% of Americas 95 million households.

According to EIA/CEG's Shapiro, new information technologies are also driving the home office boom, a phenomenon that shows no sign of abating. In fact, with CD-ROM multimedia products now multiplying on the mass market, EIA/CEG believes that more and more American households will want the home office capability. CD-ROMs are providing new business information sources, and a wealth of powerful, affordable software now enables home office workers to produce business documents with an array of sophisticated features hardly distinguishable from the corporate headquarters product.

Last January, EIA/CEG forecast that 1995 sales of home information equipment to US dealers would total nearly $24 billion or nearly one-third of the year's industry-wide sales, and that trend has continued. For the past two years, home office equipment has been the fastest-growing product category, and revenues from personal computer sales aloe now equal or exceed those from direct=view colour television, traditionally the industry's best-selling product.

EIA forecasts 1995 US factory revenues of about $11.9 billion for personal computers. In addition to PCs, other types of consumer electronics equipment are contributing to the American home office trend. The consumer demand for facsimile machines remains strong. More than 2.5 million of these machines were sold to US consumers in 1994, with a factory value of almost $1 billion. EIA/CEG's forecast for 1995 calls for sales of almost 3 million units with a factory value of well over $1 billion. Home photocopier sales are brisk, with 1994 sales of about half a million units, and at least that many forecast for 1995. Corded and cordless telephone sales of more than 45 million units are predicted for 1995 by EIA, with a total factory value of 1.8 billion. In addition, EIA's Consumer Electronics Group estimates consumer penetration of cellular phones rose from 10% to 20% in 1994 and shows no signs of slowing. Cellular telephones represent one of the technologies making possible the mobile or virtual office, so called because extremely compact cellular phones, paging devices, notebook PCs with modems, portable faxes, and portable digital assistants (PDAs) now permit a business person to carry an office virtually anywhere, from a moving automobile to a hotel room.

EIA's Gary Shapiro thinks the American mobile office trend will continue to gain momentum: "My guess is that during this decade we will see a wave of innovation in wireless communications hat will surpass even the cellular revolution of the Eighties in terms of technology and economic impact. Clearly, the mobile office has a bright and exciting future."

The US mobile electronics trend is so strong, in fact, that this year EUA staged a trade show devoted exclusively to automotive electronics and the mobile office – the National Mobile Electronics Show. Because the demand for mobile electronics is brisk, future versions of this annual show will continue to take place every April.

Multimedia games/education

Some of the same kinds of hardware platform and software resource that support eh home office are making the American home a computer-based entertainment and education centre as well. Spurred by the desire of parents to keep their children happy at home and provide them with a competitive edge in education, a rapidly growing selection of CD-ROM based games and learning programs is flowing into millions of American homes. Generally speaking, 'multimedia' refers to the integration and concurrent display of text, video, graphics and audio. Multimedia system are also interactive, encouraging the user to be actively involved with the hardware-software interface.

According to EIA, the number of American Households owning computers with CD-ROM totalled 14 million by the end of 1994, nearly trebling the installed base of only a year earlier. EIA expects the number to increase to 20 million in 1995, while CD-ROM software titles will continue to grow exponentially. Since 1993, CD-ROM multimedia programs have generated the most interest at the consumer electronics shows sponsored by EIA. To encourage and take advantage of this multimedia trend, beginning in 1996, EIA is sponsoring a brand-new megashow called CES Orlando, 'The Digital Destination'. The show will take place each year in Orlando, Florida, USA.

Home theatre.

Adding to the trend toward home-based entertainment is the growth of interest in large-screen (>69 cm) direct-view and projection television systems. Owing to the growing availability in the US of digital images and sound via direct broadcast satellite (DBS), together with the advent of TVs that show films in wide movie-screen proportions, stereo audio/video receivers, and surround-sound speaker systems, the concept o the home theatre has taken giant strides forward. To simulate the movie theatre experience at home, more and more Americans are buying home theatre systems or creating their own from a growing array of components. Together, US home theatre audio and video product sales increased by 12% between 1993 and 1994, amounting to ¢7 billion.

The home theatre experience tends to be built by consumers in stages. The basic experience is provided by a big-screen direct view or projection TV. The second step is usually the integration of the TV with a surround-sound

processor and extra speakers for the rear audio channels. Some consumers fill out their home theatres by adding more speakers, along with hi-fi VCRs and laserdisc players. Home theatre enthusiasts with deep pockets have their systems tailored by specialized home theatre stores, including built-in installation. Such an installation can cost $15,000 or more.

Video

Although home theatre represents the leading edge of colour video/audio technology, the great majority of US colour TV sales continue to be in the $350–$450 price range. It is not unusual today to find a 64-cm colour TV with built-in stereo in the $300 range and a 69-cm stereo colour set for as little as $400. Despite the fact that four or five colour sets purchased ten years ago are still in use and fully half of 15-year-old colour sets are still operating, Americans continue to buy them in record numbers, moving the older sets to other rooms as the new ones take centre-stage in the living room.

The appeal of colour TV is enhanced by the availability of increasingly-sophisticated, compact, and affordable VCRs, camcorders, and TV/VCR combinations. "It is remarkable that colour television, despite its 97% US household penetration, is about to record its best year ever," observed Gary Shapiro. "Even though it made its debut in this country 40 years ago, colour television continues to offers consumers new and exciting capabilities, including home theatre, direct broadcast satellite, and soon digital high-definition television (HDTV)."

Audio

The strongest trend in US audio consumer electronics continues to be the sale of compact disc players, which surpassed 24 million units in 994 and will probably total 32 million this year, with a factory value of abut $5 billion. Of those 32 million CD players, nearly 19 million will be portable units. In 1994, American consumers purchased 5.3 million rack and shelf audio system, and EIA forecasts 1995 sales of about 5.5 million units with a factory value of almost $1.5 billion.

In 1995, EIA expects separate audio component sales in the US to be worth about $1.8 billion at the factory. Nowhere is the sales synergy of video and audio more clear than in the the mutual stimulation of large-screen digital TV and digital high-end, surround-sound audio equipment. Says Gary Shapiro: "Specialty audio traditionally has had a loyal, knowledgeable following, but thanks to the home theatre boom we're seeing demographically broader demand for top-of-the-line speakers and audio/video receivers, or example. Not since the advent of digital audio itself has there been such a wave of new interest in upgrading home audio systems."

With the marriage of audio and video into he home theatre concept, audio devotees have the option of adding a digital recording capability as well, choosing between Digital Compact Cassette (DCC), a system compatible with analogue as well as new digital taps, and the MiniDisc (MD), a technology based upon the disc's magneto-optical capabilities. A lot of excitement has been generated by the discrete five-channel surround-sound made possible by Dolby AC-3, which was introduced to American consumers this year and sets a new standard for audio excellence in home theatre. Some television manufacturers are even incorporating digital signal processing in selected TV sets. DSP chips can store the acoustic characteristics of different listening environments, so listeners can choose to hear a soundtrack as if it was played, for instance, in a movie theatre, a concert hall, a jazz club, or a cathedral.

The market impacts of the home theatre trend and its audio-visual components are the focus of EIA'S NEW CES Specialty Audio and Home Theatre Show. The show features exhibits and workshops in these product categories: specialty audio hardware and software, home theatre systems, video hardware and software, custom installation products, cable and accessories and furniture, with major participation by industry publications and trade associations, as well as all the leading manufacturers.

Where do we go from here?

At this point no one can tell whether the current separate trends in US consumer electronics between the home computer as a centre of business, entertainment and educational activities and the home theatre as a centre of family entertainment and information experiences will be resolved into a single point of 'multimedia' focus in the future. Some US industry forces are trying to consolidate trends in favour of the computer, others in favour of the home theatre. In the foreseeable future, both are likely to grow in sophistication and appeal and coexist happily in the home, to the benefit of all industry participants.

CORRECTION

'Coding & Modulation Techniques in ERMES' (October 1995)

The seventh line before the end of the article (page 75) reads:

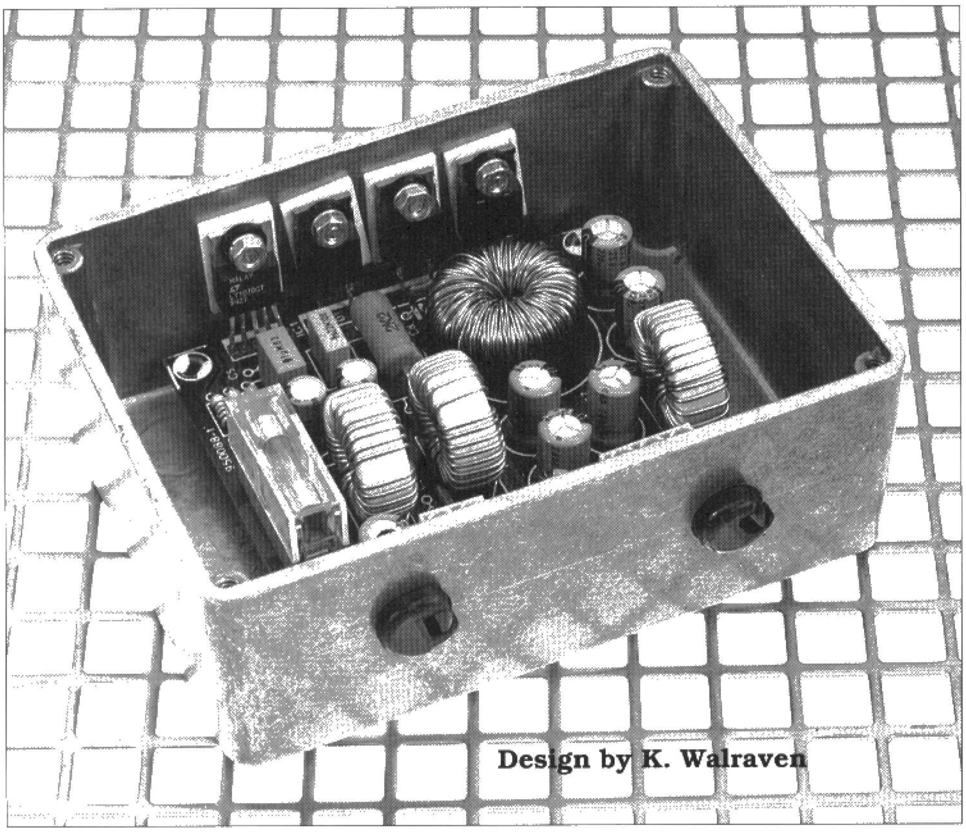
which are factors over GF(2) of $(x + 1)$.

This should read:

which are factors over GF(2) of $(x^{23} + 1)$.

SYMMETRICAL SUPPLY IN CARS

There is a problem if you want to use a car battery to power a circuit which requires a symmetrical supply voltage. Having abandoned the idea of mounting a second battery in your car for that purpose, take a serious look at the circuit discussed here. It converts the car battery voltage into symmetrical ±12 V or even ±15 V rails. Since the converter is able to supply a continuous output current of about 0.5 A, and a peak current of up to 1 A, it is eminently suited to powering control amplifiers and small power amplifiers.



Design by K. Walraven

IF you want to obtain a symmetrical supply voltage of ±12 V from a car battery, it is always necessary to first double the battery voltage. The only way to 'step up' a direct voltage is by using a switch-mode power supply. Such a DC-DC converter operates on one of two principles. Low-power supplies usually rely on a clever switching system by which capacitor charges are 'stacked' rapidly to give the higher voltage. If more output current is demanded, however, DC-DC converters almost invariably use an inductor for energy storage. By periodically interrupting the current through an inductor, a relatively high induction voltage is generated. This voltage may be rectified and stabilized, but it may also be 'stepped up' beforehand.

Flyback principle

Two concepts are available for the design of a DC-DC converter based on the 'switched-inductor' principle. The best known are the forward converter, the boost converter and the flyback converter. Only the latter is considered here because it is applied in the practical circuit discussed further on.

The principle is illustrated in **Fig. 1**. While the switch is closed, the current flowing through the inductor causes a magnetic field to be built up in the inductor core. During that period, no current flows through load resistor *R*. When the switch is opened, the inductor starts to act as an energy source. The diode then ensures that the current supplied by the inductor flows through the load. Although the output voltage may be taken directly from the inductor, it is also possible to replace the inductor by a transformer.

As regards the current through the inductor, there are two different operating conditions. The first is illustrated by the voltage and current graph in **Fig. 2**. After the switch is closed, energy is stored in the inductor core during period 'A' of the voltage graph. This energy is released again a little later during the period marked 'B'. Nothing happens for a while after all anergy has been released, which can be seen by the ringing of the signal during period 'C'. The lower graph shows the consequences for the current, which rises linearly during period 'A', decreases linearly again during period 'B', and drops to nought during period 'C'. Because the current drops to nought intermittently, this mode is called 'discontinuous current mode'. The advantage of this operating mode is that it allows the control system to give good response to changes in the input voltage as well as to output load variations. The disadvantage is the relatively high peak current carried by the switch.

Another possible condition is 'continuous current operation'. As illustrated by the upper curve in **Fig. 3**, all available time is then used to store energy and release it again. The period so created is even a little too short, because the inductor is still busy supplying energy at the end of the interval.

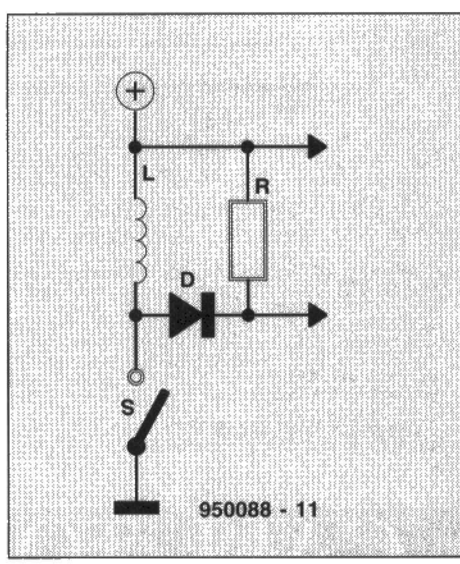


Fig. 1. As long as the switch is closed, a certain amount of energy is stored in the inductor. This energy is released when the switch is opened.

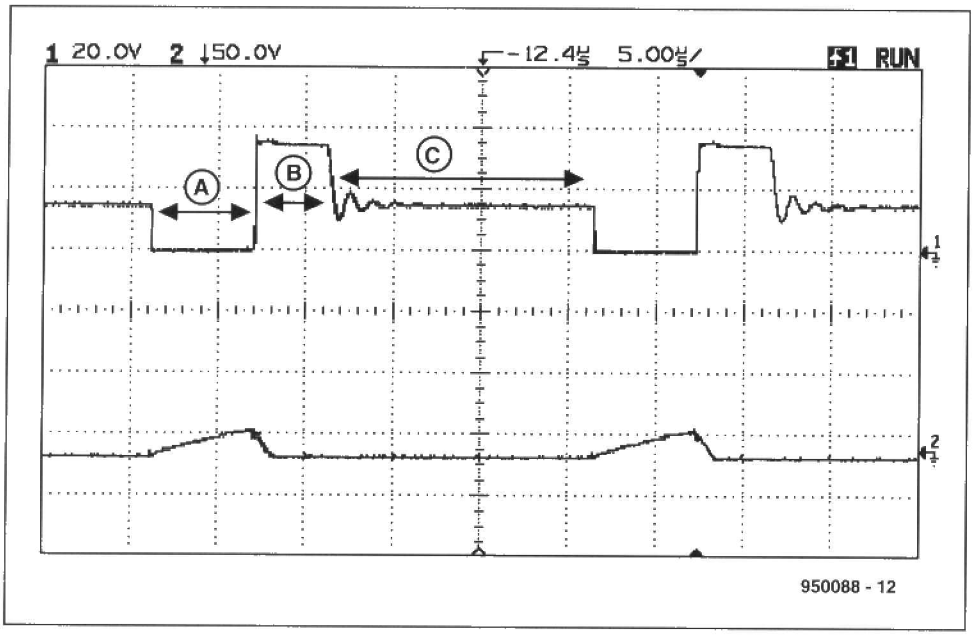


Fig. 2. Voltage and current graph of a converter in non-continuous current mode. The current graph (below) clearly shows that the current actually drops to nought between the 'down' and 'up' slopes.

This is indicated by the section marked 'D' in the current graph printed at the bottom. It shows that the current jumps immediately to a certain value when the switch is closed, and then rises linearly. Because the current does not drop to nought again at the end of the period, this is called 'continuous current mode'. An advantage of this mode is that the ripple current through the inductor is small with respect to the load current. On the down side, this mode offers not so good response to load variations.

It goes without saying that non-continuous operation is the best mode for lighter loads, while larger output currents are best handled in continuous mode. A system capable of switching between these modes depending on the current demand is, therefore, the best of both worlds. Such a control system is far from easy to stabilize, however, and that is why we have resorted to an integrated circuit which is 'easy going' and specially designed for the purpose.

The LT1070

The heart of the circuit is formed by an integrated switching regulator type LT1070. The manufacturer, Linear Technology, calls this IC a 'current mode switcher'. The internal structure of this IC is shown in **Fig. 4**. On board the LT1070 are all the standard ingredients of a switch-mode power supply. In fact, the LT1070 requires only a handful of external components. The most important elements are a robust high-efficiency switch, an oscillator and a measurement and control section. All of this is contained in a compact 5-pin TO-220 style case, so that the LT1070 is almost as easy to use as any of the familiar three-pin fixed voltage regulators. The LT1070 accepts input voltages between 3 V and 60 V, and works happily with a quiescent current of only 6 mA. Despite its 'modest' appearance, the regulator is capable of supplying a maximum output power of about 100 W without the help of an external power transistor.

The designation 'current mode switcher' means that the duty factor of the switch is controlled directly by the output current rather than the voltage. Referring to the block diagram, the switch starts to conduct at the start of every oscillator cycle. Regulation of the output voltage is achieved by changing the toggle level of the output current on the basis of the output voltage supplied by an error amplifier.

An internal low-drop regulator supplies a reference potential of 2.3 V for all circuits. The reference source allows input voltages between 3 V and 60 V to be used without any adverse effects on the performance of the IC. A 1.24-V bandgap voltage source is used as a reference for the error amplifier. The – input of the error amplifier is bonded out to a pin ('FB') and acts an the output voltage sensor. This feedback connection has a second function: when pulled low by an external resistor, the output of the error amplifier is decoupled from the comparator, and the latter is connected to the flyback amplifier. Because the output voltage is directly proportional with the flyback pulse, it may be adjusted without a direct link between input and output.

The error signal at the input of the comparator is also fed to a pin, 'V_C', which has four different functions. It is used for frequency compensation, soft-start, current limiting, and for complete shut-down of the regulator. The level at this pin is normally between 0.9 V (low output current) and 2.0 V (high output current). This voltage may be limited externally to set the maximum current. Soft-start may be implemented with the aid of a capaci-

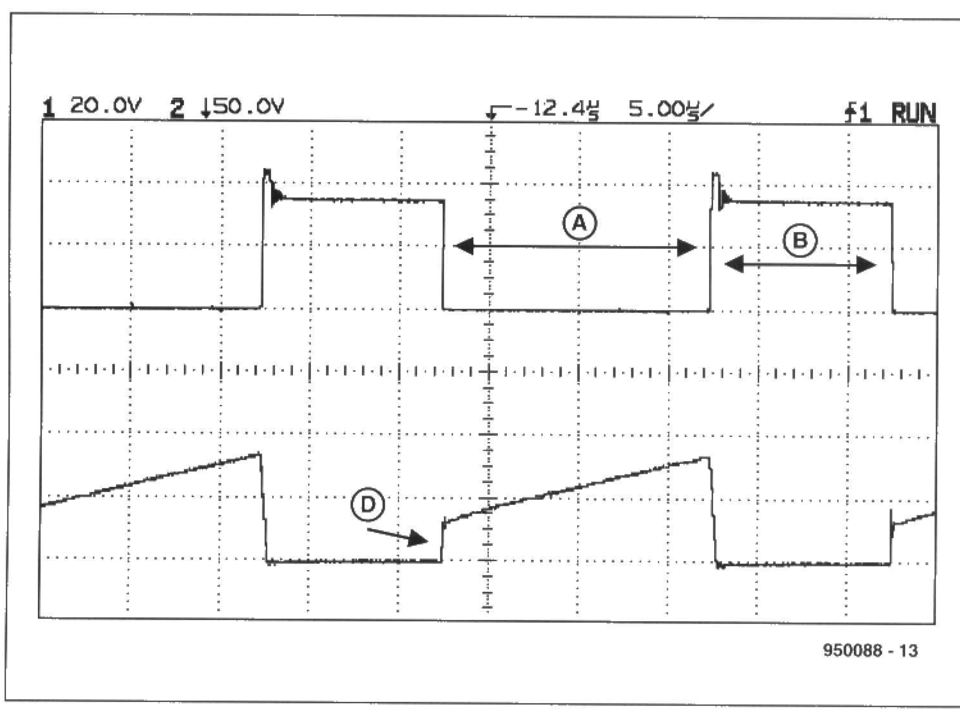


Fig. 3. The same graphs as in Fig. 2, but measured on a converter operating in continuous current mode. All available time is used to store and release energy.

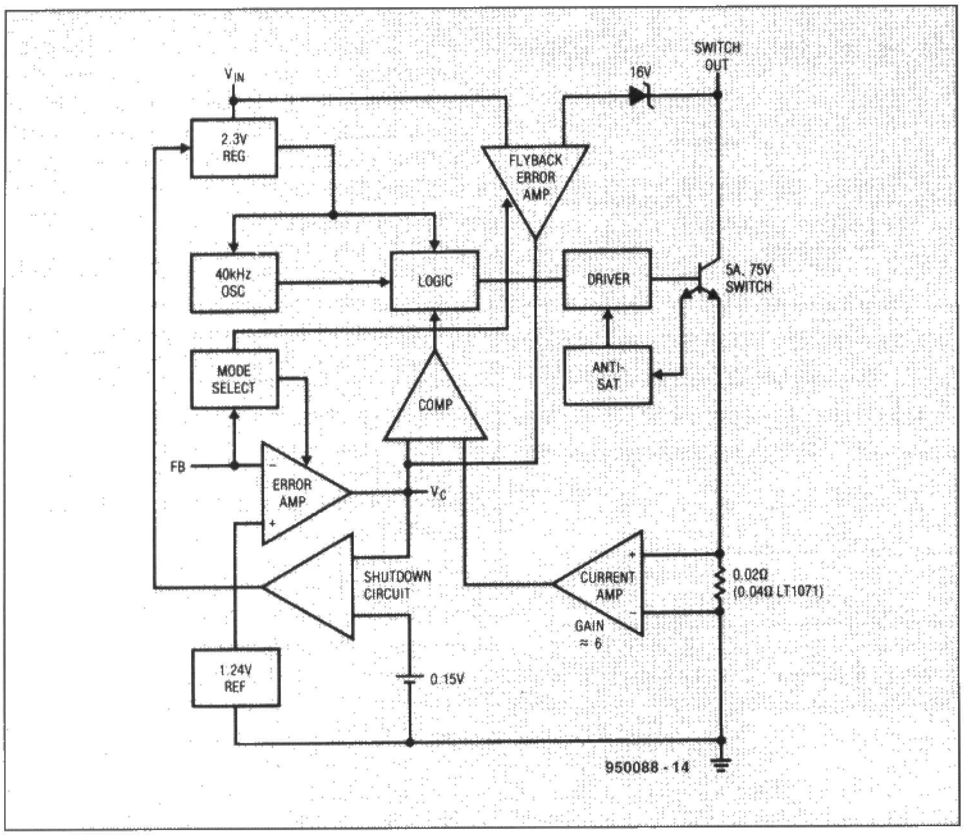


Fig. 4. The internal structure of the LT1070 is fairly complex, and contains just about everything you need to build a DC-DC converter.

tor-coupled external clamp circuit. If V_c is pulled to ground by means of a diode, the regulator enters a kind of stand-by state, while pulling the voltage under 0.15 V causes the regulator to be switched off completely. In the latter state, the quiescent current is reduced to a mere 50 µA.

Practical circuit

As already mentioned, the LT1070 works happily with a minimum of external components. Consequently, **Fig. 5** shows a very simple circuit diagram. Indeed, had we limited ourselves to the parts required for the function of DC-DC converter only, the circuit would have been even simpler, because a fair number of components serves for buffering and cleaning of the input and output voltages.

The core of the converter is actually restricted to IC_1, transformer Tr_1, the rectifiers connected to secondary windings of Tr_1, and resistor network R_3-R_4. As stated earlier, a flyback-type regulator allows the output voltage to be set by feeding (a part of) the output voltage back to the feedback input. Here, that is done with the aid of R_3 and R_4. The ratio between these two resistors therefore enables the output voltage to be set to ±12 V or ±15 V without the need of changing the turns ratio of the transformer. The resistor values indicated in the circuit diagram gave an output voltage of ±13.8 V on the prototype of the converter.

The LT1070 keeps the output voltage constant within a few millivolts (which can be measured only when changing from no load to full load). Note, however, that only the positive output voltage is used as a reference for the regulator. As long as the converter is symmetrically loaded (i.e.,

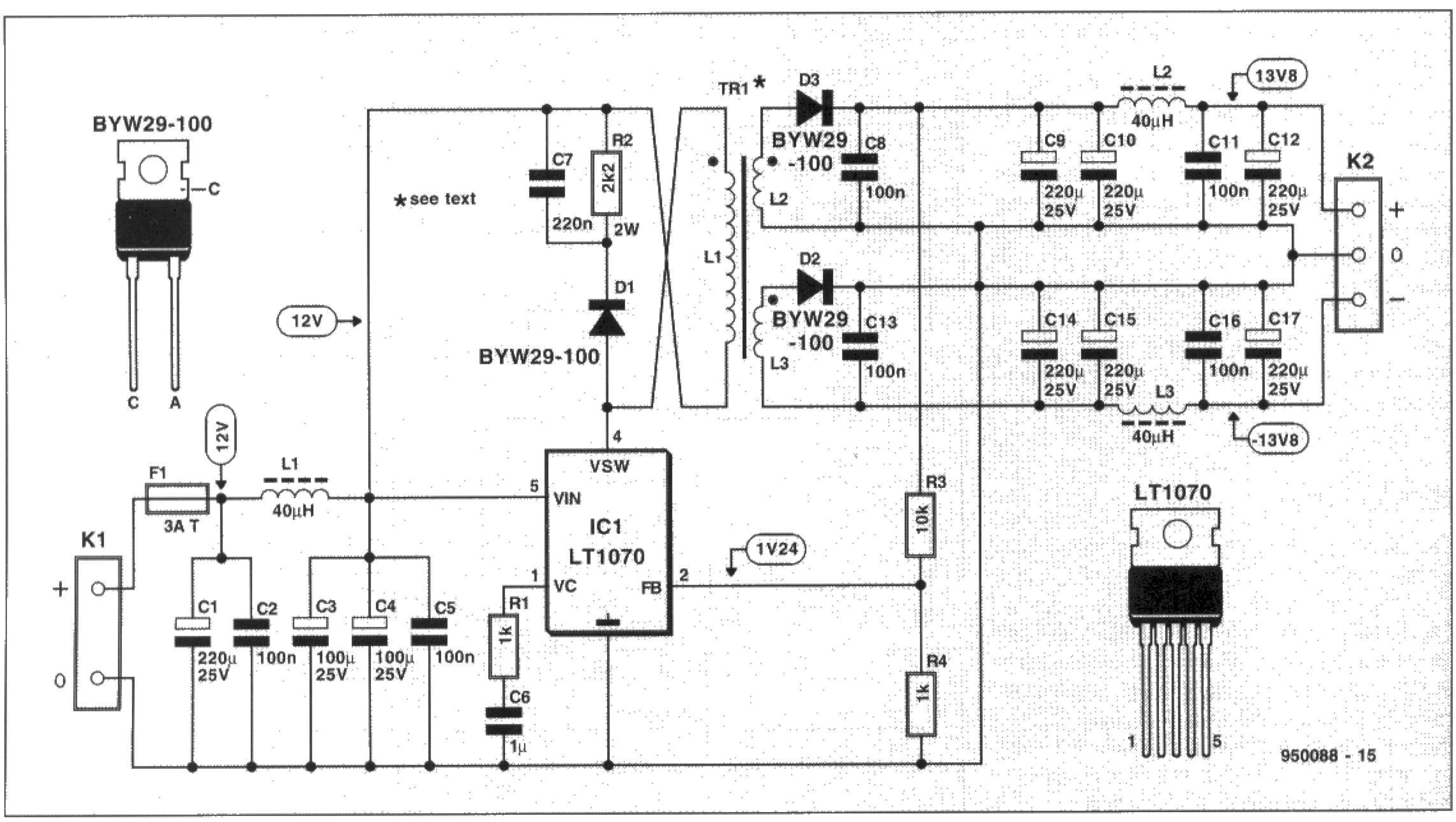


Fig. 5. Apart from the IC and the transformer, the circuit diagram contains only a double rectifier, a number of reservoir capacitors and noise suppression filters.

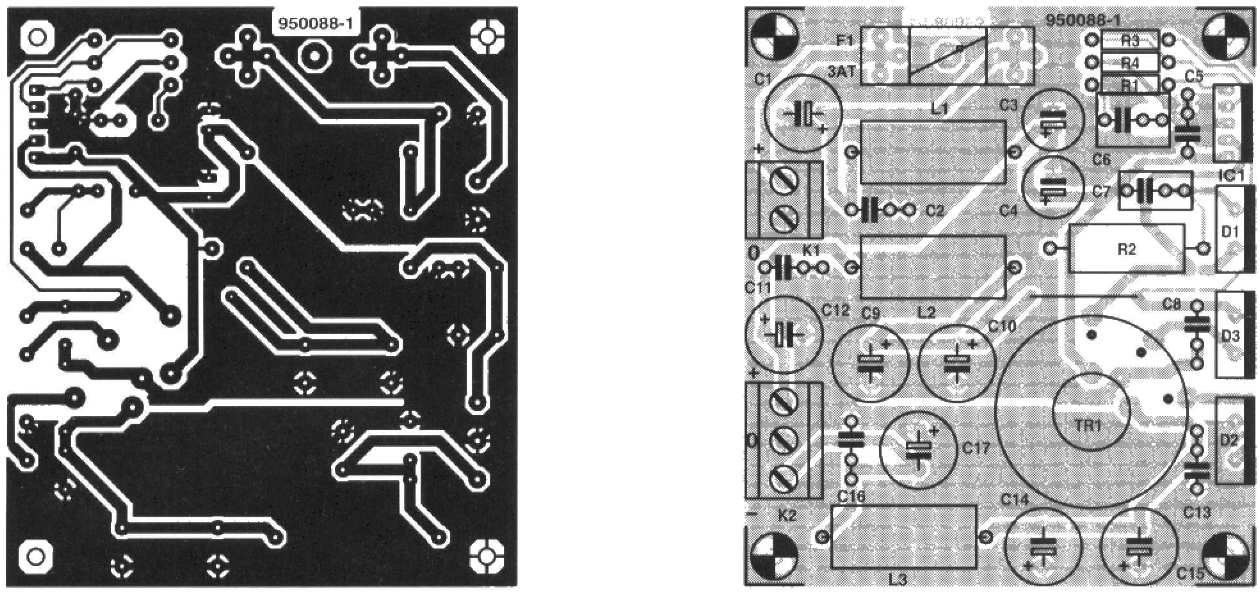


Fig. 6. Populating the board is easy. Its moderate size allows the board to be fitted in many different types of metal enclosure (board not available ready-made).

roughly equal current consumption on the positive and negative output rails), there will be no undue unbalance, and the regulation on the negative rail will be hardly worse than that on the positive rail. However, when only the negative rail is loaded, that output voltage may drop appreciably. So, if you want to load the negative rail only, be sure to provide a continuous load on the positive rail, for instance, with the aid of a resistor. If you are after a 'rock-steady' supply, connect a linear regulator to each of the converter outputs.

Components D_1, R_2 and C_7 form a so-called snubber network, which serves to prevent the LT1070's output voltage from exceeding its maximum value (65 V). Because of the stray inductance in the circuit, a large voltage surge may occur the moment the chopper switch opens. This surge is diverted via D_1 and C_7, while the capacitor, in turn, is discharged slowly by R_2.

To keep unwanted emissions to a minimum, the circuit has no fewer than three *LC* filters: one for the input voltage (L_1-C_2), and one on each of the output rails (L_2-C_{11} and L_3-C_{16}). For L_1, L_2 and L_3 it is best to use those well-known triac suppressor coils with a minimum current rating of 1 A (usually 2.5 A). If your demands are not so high, the coils may be replaced with 6-hole ferrite beads with a few turns of wire through them. Although the suppression of the 40-kHz fundamental component is then slightly less effective, the effect on higher harmonics above 500 kHz is nearly identical.

The relatively high pulse currents in the circuit cause the electrolytic reservoir capacitors to run fairly hot (up to about 50 °C). To keep their heat dissipation within reasonable limits, these capacitors are therefore fitted in pairs. To ensure the highest possible efficiency and life expectancy of the converter, it would be better to use electrolytic capacitors specially designed for use in switch-mode power supplies. However, these costly and difficult to obtain parts are not strictly required in the present circuit. Our prototype gave satisfactory results with 'ordinary' caps fitted.

Do not use ordinary diodes (like 1N4002 etc.) in positions D_1, D_2 and D_3, because they are too slow in this application. Almost any real switching diode may be used, as long as it is capable of passing a current of at least 3 A. It is best to use fast diodes with soft recovery — the latter feature is important to keep spurious emission to a minimum. The diode indicated in the circuit diagram is a Schottky type rated at 100 V, 8 A, which has an additional advantage in not dropping too much voltage.

Construction

The printed circuit board designed for the DC-DC converter is shown in **Fig. 6**. The size is modest, while the tracks are laid out generously. Populating the PCB with step-by-step reference to the component overlay and the parts list is not expected to cause undue problems. The IC and the diodes are purposely located at the edge of the board, so that they are easily secured to a heat-sink (using washers and plastic bushes). Alternatively, if you use a metal (die-cast or alu-

COMPONENTS LIST

Resistors:
R1;R4 = 1kΩ
R2 = 2kΩ2 2W
R3 = 10kΩ

Capacitors:
C1;C9;C10;C12;C14;C15;C17 = 220µF 25V radial
C2;C5;C8;C11;C13;C16 = 100nF
C3;C4 = 100µF 25V radial
C6 = 1µF MKT
C7 = 220nF

Inductors:
L1;L2;L3 = SFT10-30 or SFT1030 (40µH) (TDK)
Tr1 = SFT12-50 or SFT1240 (see text)

Semiconductors:
D1;D2;D3 = BYW29-100
IC1 = LT1070 (Linear Technology)

Miscellaneous:
K1 = 2-way PCB terminal block.
K2 = 3-way PCB terminal block.
F1 = fuse 3A (slow) w. PCB mount holder.
Metal case, e.g., Hammond 1590S, 110x82x44mm.
Insulation set (washer and bush) for IC1, D2, D3.

Most components for this project are available from C-I Electronics, P.O. Box 22089, NL-6360-AB, Nuth, The Netherlands. Fax (+31) 45 5241877

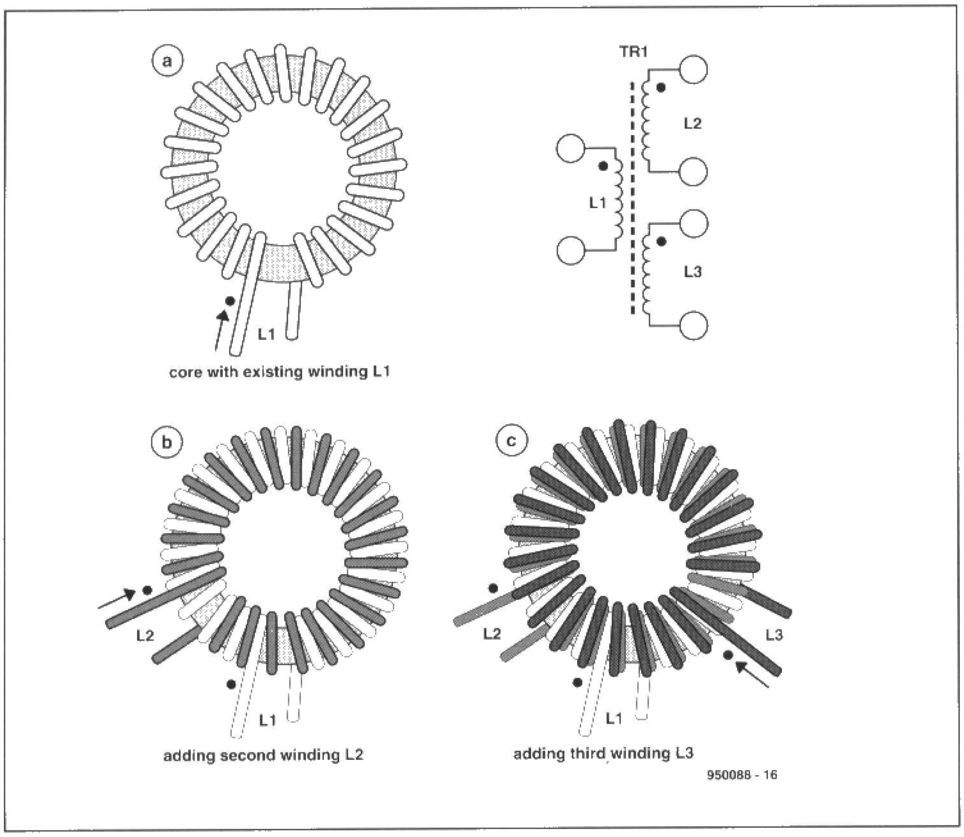


Fig. 7. Transformer Tr1 consists of a normal ring core suppressor choke, whose existing winding is used as the primary winding. A bifilar secondary is wound over the primary, observing that the winding direction is the same as that of the primary.

minium) case for the converter, that may be used as a heat-sink as well. However, we haven't got as far as fitting the board into a case. First, concentrate on making the transformer, Tr_1. The core is that of an ordinary triac suppressor coil with an inductance between 25 µH and 100 µH, and a current rating between 3 A and 5 A. The parts list states a few types that may be used. Usually, such coils have between 30 and 50 turns of enamelled copper wire on the core. This winding may be left in place, and becomes the primary winding of the transformer. Count the number of turns. Next, apply two secondary windings over the primary, each having the same number of turns as the primary. Use 0.5-mm dia (24SWG) enamelled copper wire, and wind the two secondaries simultaneously, that is, with two wires at the same time. Be sure to observe the **same winding direction as the primary**. It does not matter whether you start winding the wire from the left or the right — the thing to keep an eye on is whether the wire is inserted into the core from below or from the top. So, look carefully at how the primary is wound. Distribute the two new windings as evenly as possible across the circumference of the core. The final construction is illustrated in **Fig. 7**.

A final remark on the transformer. If a higher output voltage is desired (more than ±15 V), the efficiency of the converter may be improved by making the secondary windings a little larger — for example, 60 turns instead of 50. Fortunately, the exact number of turns is not critical, so gross errors are hard to make.

Testing and setting up

The photograph in **Fig. 8** shows the completed prototype of the converter. To be able to test the circuit properly, diode D_2 should not be fitted for the moment. Connect two 1-kΩ load resistors to the output rails of the converter (one to the positive rail and one to the negative rail). In the interest of safety, it is best at this stage to use an adjustable power supply instead of a car battery. Connect it to the converter, and increase the voltage slowly. The converter should start to work at an input voltage of between 3 V and 5 V. If you do not have an adjustable supply, connect a 12-V, 5-W lamp in series with the battery. The lamp will limit the current in case something goes wrong.

Use an oscilloscope to check the voltage at pin 4 of the LT1070 against the oscillogram in **Fig. 2**. It is essential to be able to discern three levels: zero volts, the supply voltage and the doubled supply voltage. If you find that there are only two levels, the winding direction of the secondaries on Tr_1 is wrong. Remove the transformer and wind it again.

If the waveform is okay, the input voltage may be increased to 12 V, or the lamp may be removed. The positive output voltage should then be around 13.8 V. If that is the case, D_2 may be fitted on the board. Next, run another check on the waveform shape at pin 4 of IC_1. Also check the level of the negative output voltage at the – clamp of K_2.

If the circuit behaves properly so far, it is time to increase the load current. Secure the heat-sink to the IC and the diodes, and exchange the 1-kΩ resistors with 5-watt car lamps. The waveform at both outputs should be as shown in **Fig. 3**. If you use an adjustable supply for this test, be sure to turn it up to 12 V first, and not connect the lamps until the output voltages of +12 V and –12 V are present. If you do it the other way around, the power supply may actuate its current limiter. That may happen because the converter always tries to supply the necessary output current. Where a power of, say, 12 W requires a current of 1 A at an input voltage of 12 V, that goes up to 2 A at 6 V, and 4 A at 3 V. Such output currents are beyond the capacity of most (hobby) power supplies, hence you have to start without the load connected to the converter.

For the sake of completeness, the circuit diagram shows a number of measurement values. Although the input voltage is given as 12 V nominally, the actually allowed level here is up to 15 V. Using the indicated component values and an input voltage of 12 V, the output voltage should be about ±13.8 V. This voltage may be changed within certain limits by changing the ratio between R_3 and R_4. In all cases, however, a voltage of 1.24 V (±5%) should be present at pin 2 of IC_1. If not, the regulation of the IC does not function properly. This voltage should correspond to the internal reference voltage. At a too high voltage, the output of the converter is probably not loaded, while a too low voltage at pin 2 indicates a too heavy load or a too low input voltage.

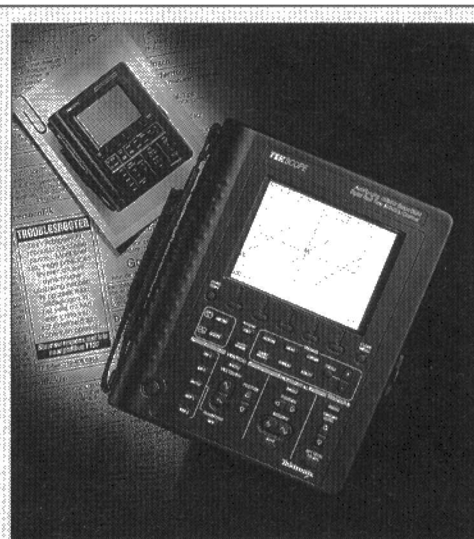
The internal regulation voltage of the IC may be measured at pin 1. This voltage depends on the output current, and changes between 1.1 V at no load to about 2 V at full load.

Final remarks

Having passed all tests and experiments without serious mishaps, the circuit is ready for the finishing touches, and the test gear and car lamps may be put away. To keep unwanted electromagnetic radiation as low as possible, the circuit should be built into a sturdy metal case. The prototype was housed in a die-cast case from Hammond. The type number is 1590S and the outside dimensions are

The WINNER of the International 1st Prize

of our International Circuit Design Competition published in the July/August 1995 magazine



International 1st prize for the Circuit Design Competition: the incredible THS720 TekScope. Will it be yours?

will be announced in the December 1995 issue of Elektor Electronics.

The winning design will also be presented!

A list of all prize winners, as well as a large part of the prize winning circuits will be published in separate sections in the January and February 1996 issues of Elektor Electronics. Don't miss these special issues! Your circuit may be in one of them!

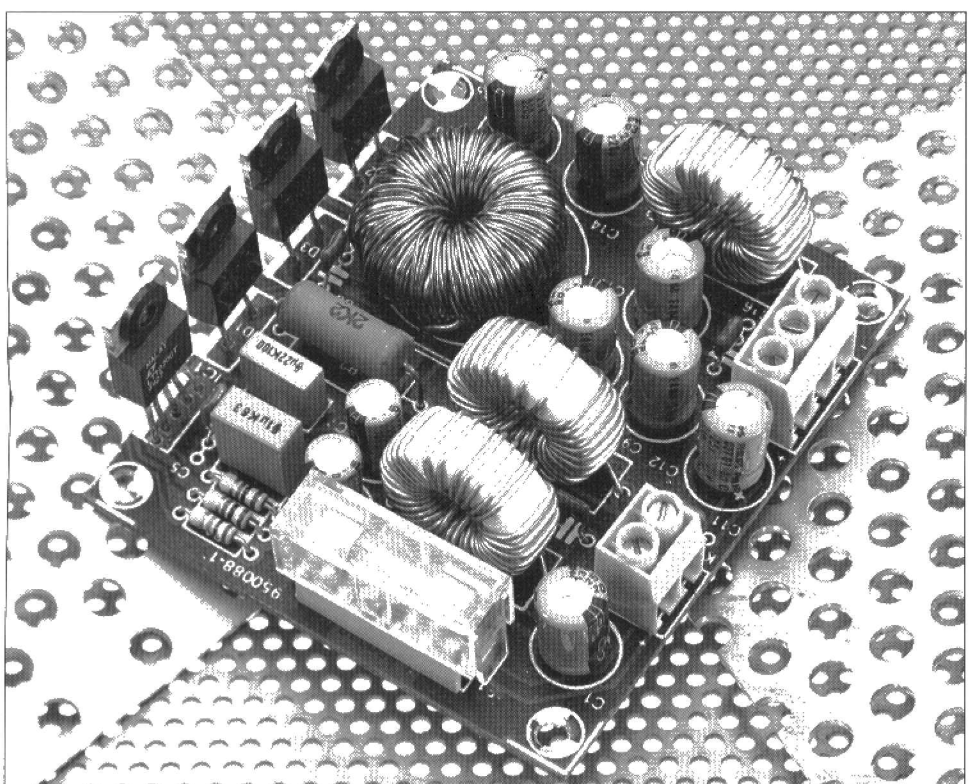


Fig. 8. Completed prototype board. Diode D2 should be omitted for the purpose of testing the circuit.

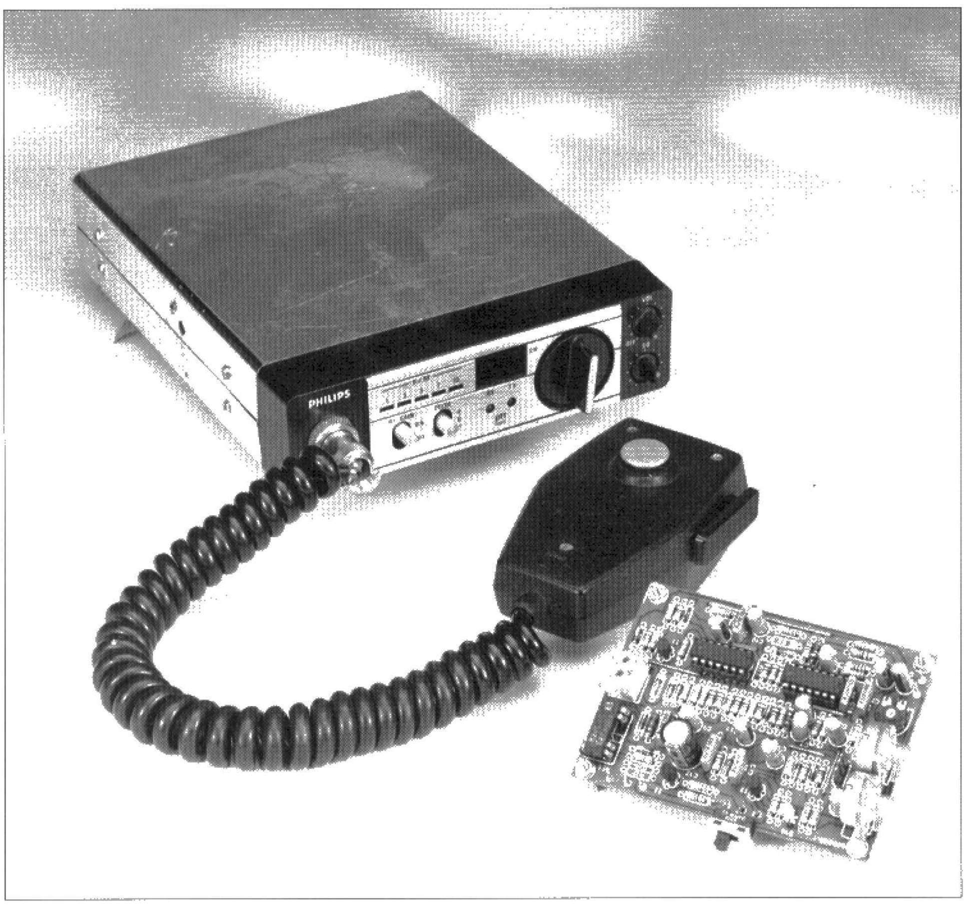
approximately 110×82×44 mm. The circuit board fits exactly in this case, and is easily secured to the bottom with the aid of four PCB pillars. The IC and the three diodes may be secured to the side panel using insulating washers. This arrangement will afford sufficient cooling for not too heavy use. The input and output cables to be connected to K_1 and K_2 enter the case through suitable grommets, and should be fitted with a heavy-duty strain relief at the inside.

As already mentioned, the converter is capable of supplying a peak output current of up to 1 A, and a continuous current of up to 0.5 A. Note, however, that these ratings are achieved at normal room temperatures only (up to about 25 °C). In the blazing sun, however, the temperature inside a car may easily reach about 60 °C, which means that the converter is not able to supply its maximum power because the thermal shut-down will be actuated much earlier than under normal circumstances. Fortunately, the same thermal protection ensures that the IC can not be damaged or destroyed by high temperatures.

(950088)

FM NOISE SQUELCH

Although the squelch (noise suppression) function on most narrow-FM transceivers (including CB rigs) will work fine without too much attention being paid to it, there is always room for improvement. In this article we look at a better squelch which is intelligent enough to suppress almost anything you do not want to hear, including those nasty 'empty' carriers, constant whistles and a lot of other interference which always seems to be around, particularly when going mobile. At the same time, the FM noise squelch maintains a variable switching threshold to make sure that you can hear the other station even if its signal swings back and forth between S9+ and just about the minimum detection level of your radio. Suitable for any CB or radio amateur transceiver with a selective tone-call extension socket.



Design by Stefan Meyer, DL9BE

THE function of a squelch circuit is to suppress the noise produced by an FM (frequency modulation) detector when no signal is being received. Squelch circuits have been used since the introduction of FM portable and mobile communication equipment for short-range communication during the second world war, and the operating principle has remained basically unchanged for over 50 years: rectify the noise produced by the FM detector, and use the direct voltage so obtained to control an audio switch. The function is simple: when a station is received, it will 'push down' the noise, so that the switch opens, and the message becomes audible. Thus, when no station is received, the demodulator noise is muted by the squelch, and you hear ... nothing!

The only adjustment available on most traditional squelch functions is the trip level, or sensitivity. In most cases, this is set such that the receiver just quiets when no signal is received. This corresponds to maximum sensitivity, because any signal, however small, reduces the FM detector noise, and causes the squelch to open. Although it guarantees that you are listening at the highest possible sensitivity, and you won't miss anything that is going on the channel, this setting will also cause a lot of erratic opening and closing of the squelch by noise and other spurious signals. On the other hand, if you turn up the squelch too far, weak signals may not be heard at all because they are below the switching threshold. Missed anything on the channel? Yes, 'fraid so!

Another well-known effect of the traditional FM squelch is the noise burst produced just after the received signal disappears from the channel. You can hear this type of noise in almost any police series on TV or in films (at least the realistic ones), whenever some kind of mobile communication is used. The effect is invariably linked to the above mentioned 'sensitive' setting, and caused by the 'slow' closing of the audio switch in the receiver, which allows a few hundreds of milliseconds of detector noise to pass at full strength. In one of those unforgettable episodes of the TV series *The Young Ones*, Neil, the sluggish hippie student, was disguised as a police officer posting in front of the students' residence, carrying a portable radio and all. Until instructed by HQ, over the radio, to actually produce the squelch-closing noise before releasing the transmit button, Neil's messages were simply ignored because HQ deemed them not authentic. After some practicing at uttering the squelch trailing sound into the microphone, Neil did fabulously at this, maintaining 'really heavy' communication with HQ from his post on the sidewalk. Unfortunately in spite of his efforts he ended up being arrested and beaten up anyway (as expected).

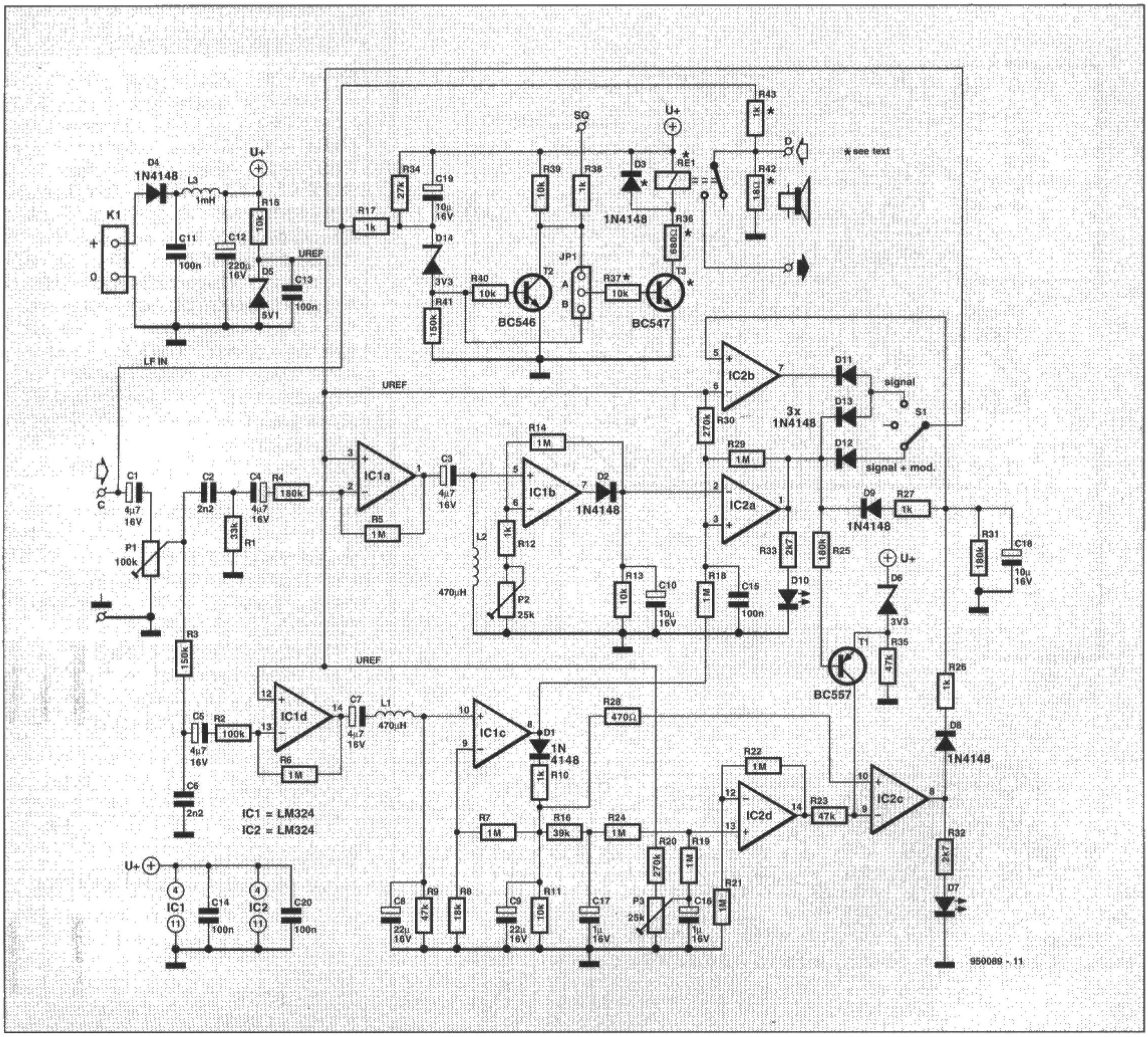


Fig. 1. Circuit diagram of the FM Noise Squelch. The parts marked with an asterisk are only required if your transceiver has no connection at all for an external selective call unit.

How it works

Okay so we want to do something about this receiver sputtering and the spurious noises coming through when the squelch is set to the most sensitive level. At the same time, we do not want to miss anything of what is going on the channel. This requirement calls for an improved squelch, in other words, one which does not respond to FM detector noise only.

The present circuit makes use of the signal connections found on either the microphone socket or the selective tone call extension socket which is available on most CB radios. The crux of the FM noise squelch is that it uses the so-called 'constant audio' signal which is available on these connectors. With reference to the circuit diagram in **Fig. 1**, this signal is applied to the LF input of the circuit. Behind the sensitivity control, P_1, the signal takes two paths. The upper path is a fairly traditional noise level detector, while the lower path serves to make the squelch respond to signals which do have modulation which varies, as opposed to 'empty' carriers and constant whistles.

The constant audio signal taken from the transceiver's selective tone call extension socket is amplified by IC1a and then fed to high-pass filter C_3-L_2 which ensures that the higher-frequency components, i.e., the noise, are amplified again (by IC_{1b}) and then rectified by D_2-C_{10}. Remember, the AF bandwidth of most speech signals in CB rigs has a limited range of about 500 Hz to 2.5 kHz. This makes it fairly easy to create a noise filter with a single *LC* combination. The 'trip' level of the squelch is set with potentiometer P_2. The voltage across C_{10} is connected to the inverting (–) input of comparator IC_{2a}, and drops when a signal is received. LED D_{10} lights when a carrier is received (with or without modulation).

The 'lower' signal path looks very similar to the upper path with the exception of the low-pass filter, L_1-C_8, connected ahead of the second amplifier, IC_{1c}. The rectifier is also nearly identical, except that it is laid out to detect signals in the above mentioned speech range. Intermittent audio signals, such as speech, do not produce a voltage across C_{17} which is high

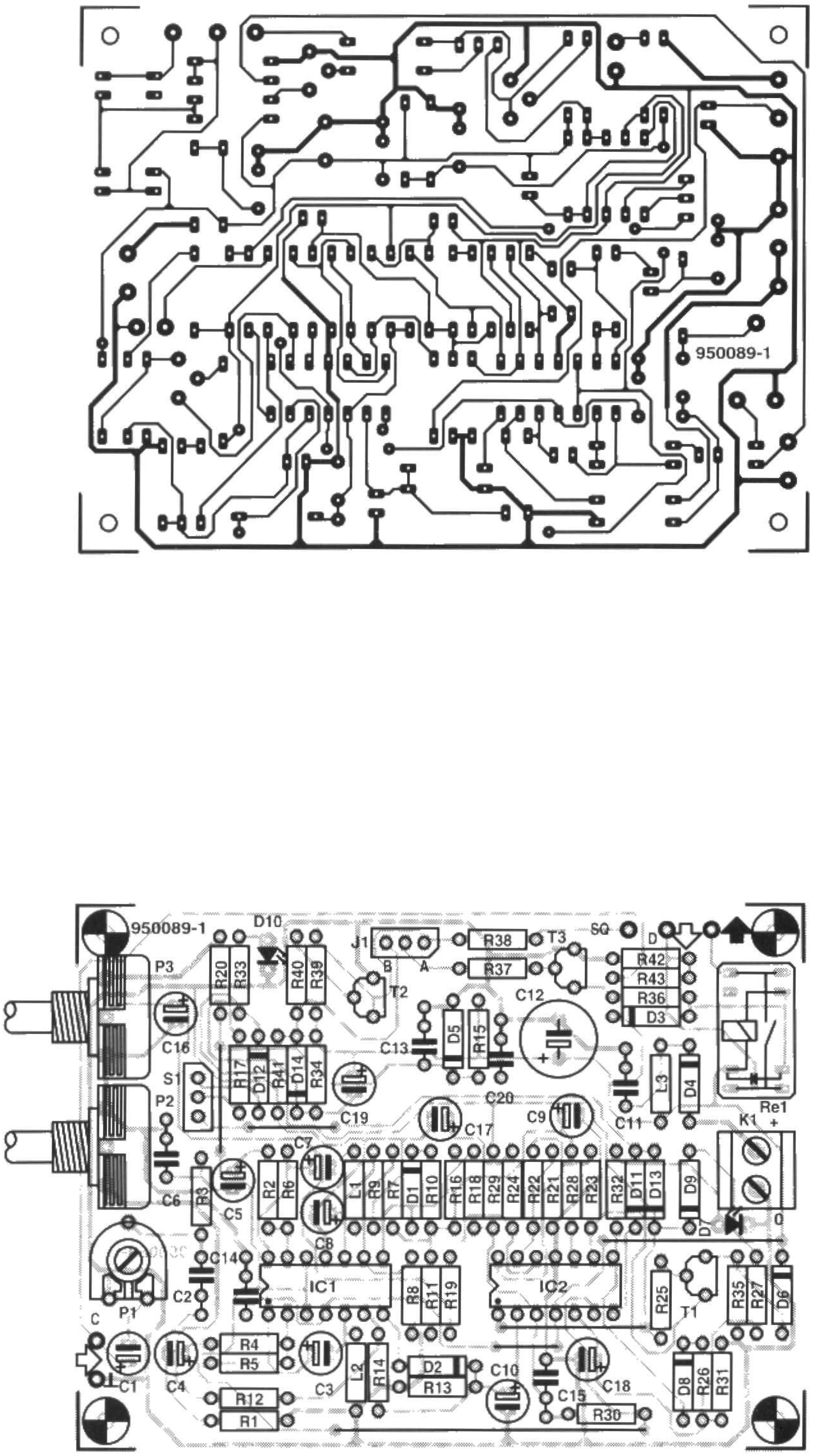


Fig. 2. Build the circuit on this printed circuit board (available ready-made through the Readers Services, see page 70).

COMPONENTS LIST

Resistors:
R1 = 33kΩ
R2 = 100kΩ
R3,R41 = 150kΩ
R4,R25,R31 = 180kΩ
R5;R6;R7,R14,R18,R19,R21,R22,R24, R29 = 1MΩ
R8 = 18kΩ
R9,R23,R35 = 47kΩ
R10,R12,R17,R26,R27,R38,R43 = 1kΩ
R11,R13,R15,R37,R39,R40 = 10kΩ
R16 = 39kΩ
R20,R30 = 270kΩ
R28 = 470Ω
R32,R33 = 2kΩ7
R34 = 27kΩ
R36 = 680Ω
R42 = 18Ω
P1 = 100kΩ
P2,P3 = 22kΩ linear

Capacitors:
C1,C3,C4,C5,C7 = 4µF7 16V radial
C2,C6 = 2nF2
C8,C9 = 22µF 16V radial
C11,C13,C14,C15,C20 = 100nF
C12 = 220µF 16V radial
C16,C17 = 1µF 16V radial
C10,C18,C19 = 10µF 16V radial

Inductors:
L1,L2 = 470µH
L3 = 1mH

Semiconductors:
D1-D4,D8,D9,D11,D12,D13 = 1N4148
D5 = 5V1/400mW
D7,D10 = LED
D6,D14 = 3V3/400mW
T1 = BC557
T2,T3 = BC547
IC1,IC2 = LM324

Miscellaneous:
JP1 = 3-way SIL pin header w. jumper.
K1 = 2-way PCB terminal block, pitch 5mm.
S1 = switch, SPDT, w. centre-off position.
Re1 = DIL relay, 12V coil, 1 make contact, e.g., Siemens type V32100-V4012-A000.
PCB type 950089-1 (see page 70).

enough to exceed the d.c. level set with the 'modulation sensitivity' control, P_3. The result is that the 'modulation' LED, D_7, flashes in the rhythm of the speech. This stage has a kind of memory function, which keeps the squelch open for about 2.5 s. If no signal (that is, modulation) is detected within this period, the output is switched off again. Assuming that modulation is present, capacitor C_{18} is ultimately charged to a level when the reference voltage at the – input of comparator IC_{2b} is exceeded. Because the level at the + input of IC_{2c} varies along with the voltage on C_9, the trip level of the 'modulation' switch varies in a natural, tracking, manner. The range of the sensitivity control, P_3, is such that weak, intermittent signals are copied reliably, while strong audible interference can be blocked if the control is turned up. Assuming that switch S_1 is set to the 'Signal & Modulation' position, the squelch switching signal is passed to another smoothing filter, C_{19}-R_{34}, and then to the base of switching transistor T_2. The squelch control signal which is fed back into the receiver is available at the collector of T_2. A jumper, JP_1, is used only for the simplest version of the noise squelch, with receivers that do not

have an external squelch control input. The circuit then breaks and closes the loudspeaker line with the aid of relay. More about this option further on in this article.

When switch S_1 is set to the centre position, the FM noise squelch is disabled. Note that the circuit is not electrically off.

When S_1 is set to position 'Signal', the squelch acts on FM detector noise only, i.e., the modulation detection feature is then not used.

Power for the FM noise squelch is obtained from the receiver. The 12-14 V input voltage is filtered by L_3-C_{12}. A zener diode, D_5, is used to provide a 5.1 V (approximately) reference voltage for use by the opamps in the circuit.

Construction

Construction of the circuit is not at all difficult, and best carried out on the printed circuit board shown in **Fig. 2**. Start by fitting the seven wire links on the board, so that they are not forgotten later. The remainder of the construction is all straightforward fitting and soldering. Check your work by keeping an exact match between the parts list and the component overlay. Pay attention when a part is polarized (which includes all electrolytic capacitors, diodes and ICs). The two potentiometers are soldered directly on to the PCB, so that their threaded parts can be used to secure the board to the front panel of the case. The mode selection switch, S_1, may need to be wired externally, depending on the type of enclosure you use. Note that a toggle switch with centre-off position must be used, although the introductory photograph shows a two-position slide switch.

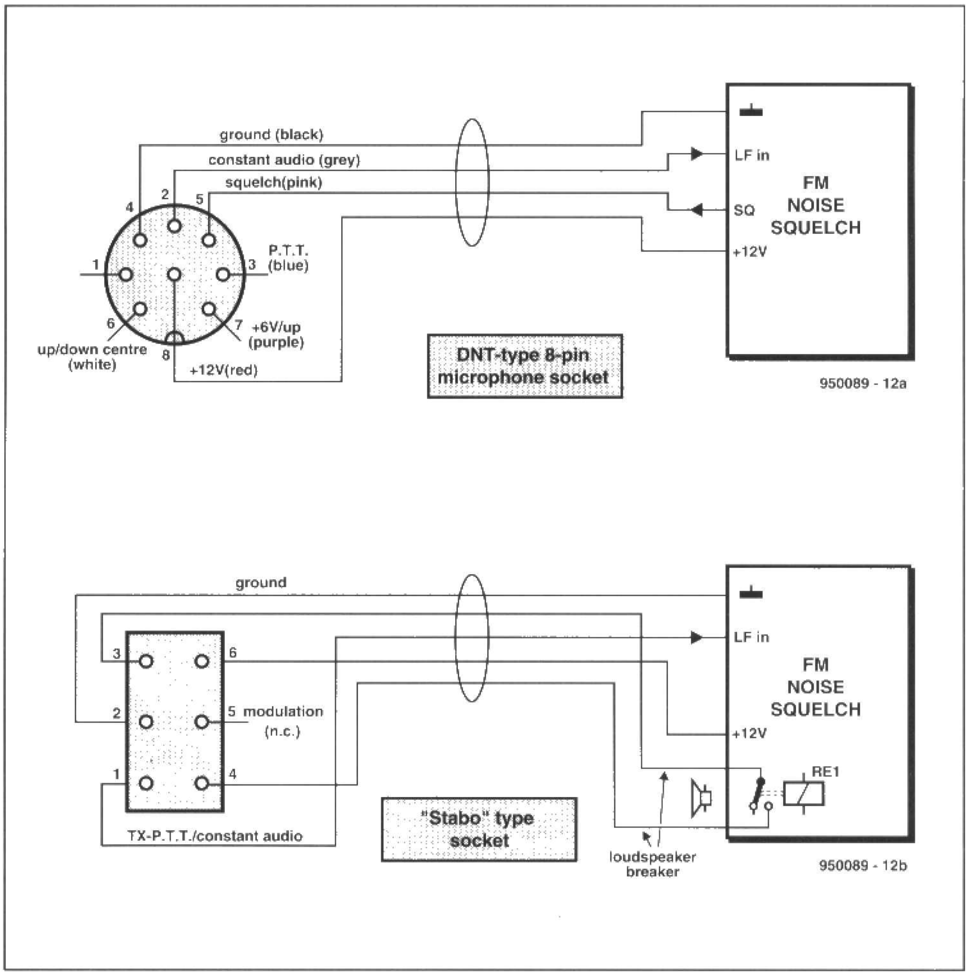


Fig. 3. Connection diagrams for 'DNT' (3a) and 'Stabo' (3b) type CB transceivers.

The connections to the 8-way microphone socket on the case are made as shown in **Fig. 3a**. This connection is used with 'DNT' type radios which support the connection of a selective call extension unit via the microphone socket. These radios include the 'Carat', 'dnt Carat exclusiv', 'dnt Strato' and 'dnt Strato plus'. The entire relay driver section consisting of the components marked with an asterisk (*) in the circuit diagram may be omitted. The FM noise squelch is connected to the transceivers's 8-way microphone socket using a short cable. The microphone is then connected to an 8-way socket on the FM noise squelch.

Users of 'Stabo' type CB transceivers should refer to the connection diagram in **Fig. 3b**. This is based on the 6-way selective call extension socket which is available on these rigs, for instance, the Stabo XM4012, XM4012N, XF4012, XF4012N, Pan Mega-Top, Astracom MA4012, and a number of 'Kaiser' CB radios. The connection should also be suitable for CB radios which have no selective call extension socket at all. Note, however, that retro-fitting such an extension has a few important implications. First, it requires the technical documentation of the transceiver; second, it voids the guarantee you may have on the equipment, and, third, it may not be allowed as regards the CEPT regulations for CB transceivers. So you do it at your own risk. Note that the 'Stabo' option also allows the relay driver section to be omitted as mentioned above. If you use a 'T' type adaptor, it is still possible to connect a selective call unit.

The last, admittedly primitive, option is to use the FM noise squelch in combination with the external loudspeaker connector which is available on almost any transceiver. This option is the only one that does require the relay and relay driver components to be fitted because it requires the loudspeaker signal to be interrupted and fed through the circuit. It is only recommended as a last resort with radios which do not have any type of selective call connection. The disadvantage of this connection is that the adjustment of the FM noise squelch transceiver should be changed with every change in the volume setting of the transceiver. Very awkward, indeed, particularly when going mobile. Also, it requires a separate 12-V power supply.

Adjustment

Adjustment of the FM noise squelch is limited to matching the input sensitivity to the level of the 'const. audio' signal taken from your transceiver. You guessed it, that is where preset P_1 comes in. For easy adjustment, the preset should be accessible through a small hole drilled in the case. Although the FM noise squelch should work quite well with P_1 set to about mid-travel, the correct range of the 'Signal' control is only obtained if the sensitivity is accurately adjusted. This is done as follows.

Disconnect the antenna from the radio. Connect the FM noise squelch to the radio. Do not push the PTT switch at any time during the adjustment. Although doing so will not harm the FM noise squelch, it may endanger the life of the (expensive) RF output amplifier in the radio because there is no load at the output. Select a channel which is totally clear, i.e. produces nothing but noise. Set the mode switch on the FM noise squelch to 'Signal',

and turn the 'Signal' pot, P_2, fully counter-clockwise (lowest sensitivity). Next, carefully adjust P_1 until the signal detection switches on, as indicates by the lighting of the red LED (D_{10}). Because of the hysteresis effect, the switch-on and switch-off point will not be occur at the same setting of P_1. This effect is transferred to the 'Signal' control. You can check this by turning it clockwise, until the red LED goes out, and counter-clockwise again until the LED comes on again. The toggle points will not occur at the same settings. However, returning the 'Signal' control to the zero position (fully counter-clockwise) should cause the squelch to open, and the red LED to light. Now you may twiddle P_1 a bit to put the squelch open/closed point at the desired setting of the 'Signal' control. In most cases, this should be about '⅛th open'. If the FM noise squelch shows no function at this stage, there is something wrong with your construction, or with the selective call extension socket.

Practical use

Most users of CB radios will know perfectly well how to use the normal squelch function on the rig. As already mentioned, the FM noise squelch has three modes: (1) Signal, (2) Off, (3) Signal & Modulation. Each of these is briefly discussed below.

The first mode, 'Signal', works very much like the traditional squelch, only the trip level is moved to a control on the FM noise squelch unit. Note, however, that the FM noise squelch offers superior performance over the radio's internal squelch because it does not, for one thing, produce the loud noise trailer traditionally heard when a station goes off the air, and the squelch is set to highest sensitivity. Also, the FM noise squelch is not controlled on the basis of received field strength only. By contrast, many CB users will know that no setting of the traditional squelch is adequate for all purposes; if set to low, a lot of noise may come through; if set too high, you may not hear the other station at all because it is not strong enough. In practice, it will be found that the 'Signal' mode of the FM noise squelch gives far better performance in this respect, and requires only occasional re-adjustment to match the received signal conditions.

The second mode, 'Off', does not actually switch off the squelch. Instead, it ignores the output signals of ther noise and modulation deetctors, and so allows every signal produced by the receiver (including FM detector noise) to reach the audio amplifier. This mode is useful if you want to 'dredge the noise' for extremely weak signals (not very useful with FM, though).

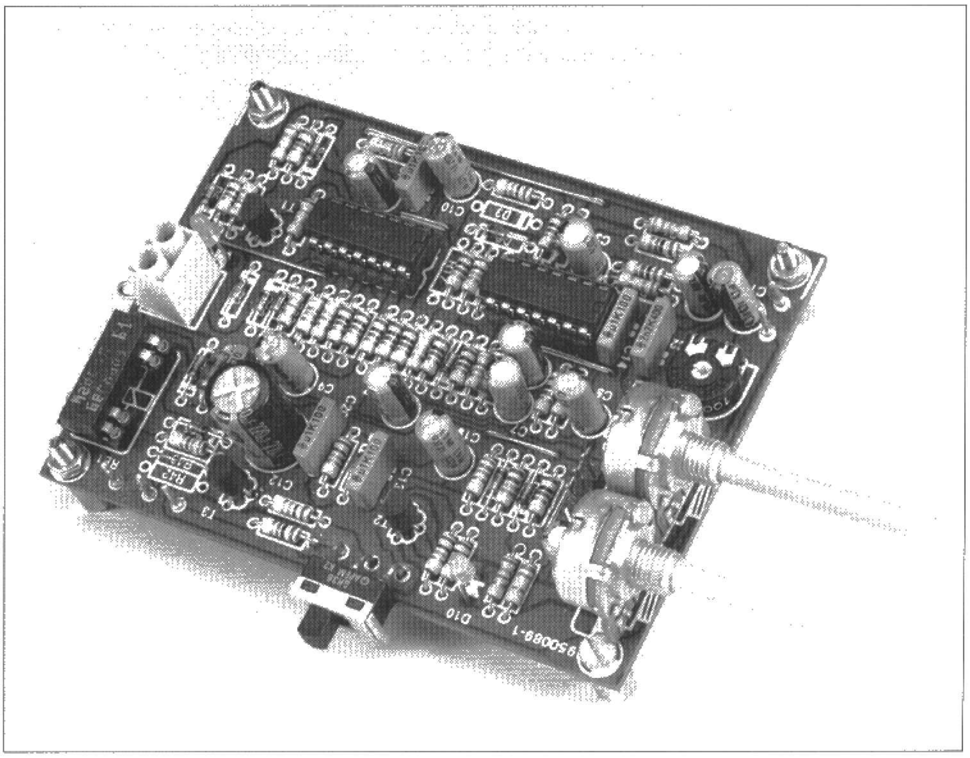
The third mode, 'Signal & Modulation' combines the 'Signal' mode with a detector for modulation on the carrier. In essence, an audible but varying signal (like rapid speech!) must be present for the squelch to open. Consequently, empty carriers as well as constant 'whistles' and other 'long' audio noises are blocked depending on the level set with the 'Modulation' control on the front panel. If you are receiving a calm speaker, though, who puts up an otherwise strong enough signal, the squelch may open and close intermittently. If that happens, switch to 'Signal' mode. Fortunately, calm speakers are few and far between on the CB channels these days. Provided the 'Modulation' control is turned up far enough, the squelch will also suppress weak AM signals.

Final points

It should be noted that the circuit has a stand-by phase of 5 to 10 seconds after the transceiver is switched on. During that period, all signals are passed, which gives you some time to set the volume control to the desired level. This feature is only available, however, when the mode switch is set to 'Signal', because the modulation detector does not start to work until after a delay of about 5 seconds.

Because of its low current consumption and the small risk of a major malfunction occurring in the circuit, the FM noise squelch does not have a fuse. Instead, a small diode type 1N4148 (D_4) will burn out if anything is seriously amiss in the circuit. As usual, check out and eliminate the cause of the over-current before reconnecting the unit to the transceiver.

(950089)



JOGGING LED

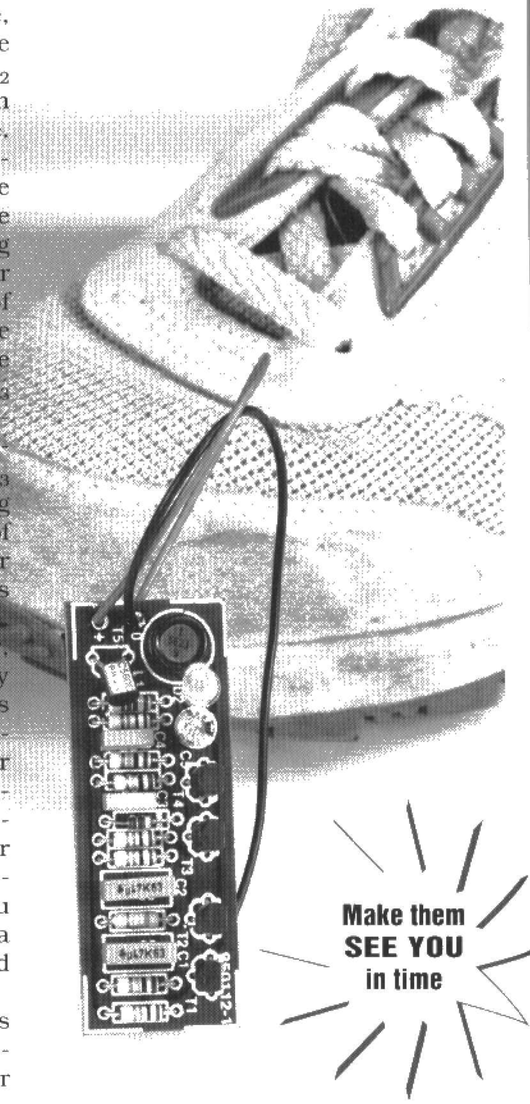
With the darkness of winter evenings on them again, joggers, walkers, hikers and long-distance runners should take heed of their safety in traffic. The jogging LED described in this article is a small circuit which emits a brightly flashing light in a steady rhythm. With the circuit attached to your arm, you will be noticed earlier by approaching traffic. Health with a secure feeling!

Design by K. Walraven

SPORT and exercise in general is beneficial for your health. One of the most popular ways of improving your general physique is to go jogging for, say, half an hour twice a week. Although it has undeniable beneficial effects, jogging may, unfortunately, put you at risk in traffic. Particularly on winter evenings, running along dark roads, streets and alleys is far from safe. Consequently, much sports clothing has reflecting bands which light up in the dark when illuminated by vehicle and street lighting, so that a runner wearing this gear is seen in time. Unfortunately, the lights on many cars, motorcycles and cyclists on the road in the dark leaves much to be desired. It is, therefore, wise for any runner to look after his or her own safety in an active way. The jogging LED described here is perfect for that purpose because it affords extra security. Attached to the arm, the circuit draws the attention of traffic behind as well as in front of you by a bright red LED which flashes at a quiet rate. Thanks to the economical design of the circuit, a standard battery affords many hours of extra safety.

The circuit

The circuit was designed with simplicity and ease of construction in mind. As shown in **Fig. 1** there are only ordinary transistors, no ICs or expensive components. The operation of the circuit will be easy to understand for most of you. Basically, the circuit is built around two cascaded, discrete, astable multivibrators, and an active output stage. Transistors T_1 and T_2 form a multivibrator which supplies an asymmetrical rectangular wave. During the 'long' time of the wave (approx. 255 ms), the output level at the collector of T_2 is low, and the rest of the circuit is in a stand-by state. During this 'low' period, the second oscillator is stopped via D_1 because the base of T_4 is held low all the time. During the short 'high' time (approx. 30 ms) at the collector of T_2, the oscillator around T_3 and T_4 is allowed to operate. This second oscillator also generates an asymmetrical rectangular wave (because C_3 and C_4 have different values). As long as there is a low level at the collector of T_4, transistor T_5 is driven via resistor R_9. This causes a current of a few tens of milli-amps through inductor L_1. When T_5 is switched of, the inductor, because of its self-inductance, will try to maintain the current flow. That is only possible via LED D_2, which requires a voltage which is slightly higher than the battery voltage (1.5 V) for forward biasing. The inductor is, therefore, only used to generate a higher voltage for the LED. The voltage increase is even more important if you use a NiCd battery, which supplies a maximum voltage of 1.2 V as opposed to 1.5 V for a dry battery.



The actual operation of the circuit is illustrated by the two oscilloscope pictures in **Fig. 2** and **Fig. 3**. The upper trace in Fig. 2 shows the collector voltage of T_2. The level of this signal corresponds to the supply voltage, which is 1.5 V. The pulse repeat rate is about 4.5 Hz (220 ms), while the pulse width is about 30 ms.

The lower trace shows the voltage at the collector of T_4. Note that the timebase for this trace is set differently. Actually, the difference with the upper trace is a factor of 50. Consequently, there is no relation between signals in the two channels. Roughly at the centre of the image, the second oscillator starts to run, generating a frequency of about 3.2 kHz at a duty factor which is just over 0.5.

The oscillogram in **Fig. 3** shows the voltage waveform at the collector of T_5. Initially, the transistor is switched off, and its collector voltage is nought. As

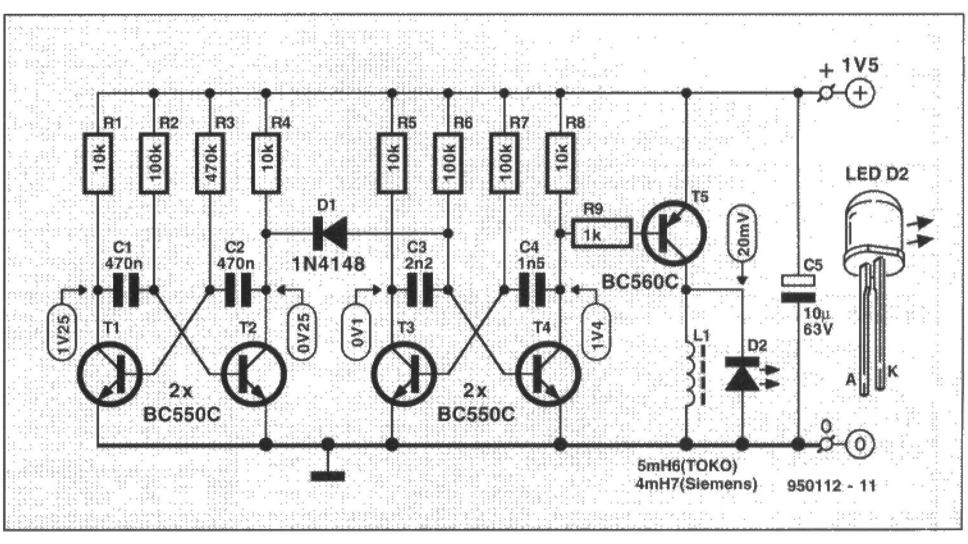


Fig. 1. Circuit diagram of the jogging LED. An inexpensive unit which gives a lot of extra security to joggers, runners and walkers on the public road.

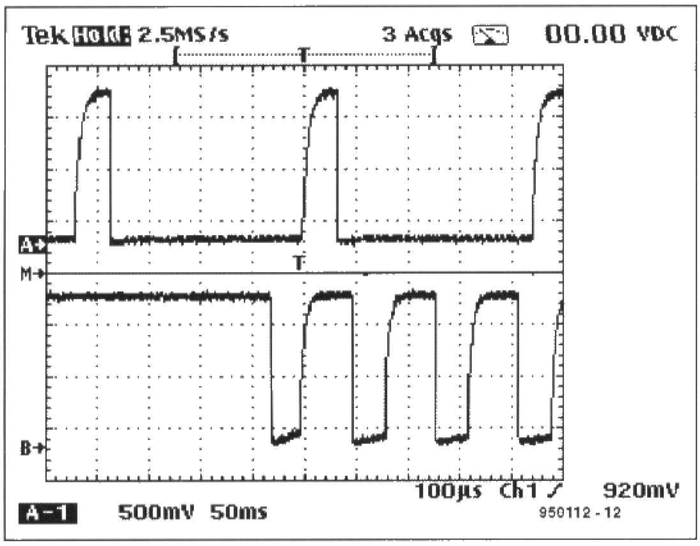


Fig. 2. Oscillogram showing the voltage waveform at the collector of T2 (upper trace) and T4 (lower trace). Note that the traces have totally different timebase settings.

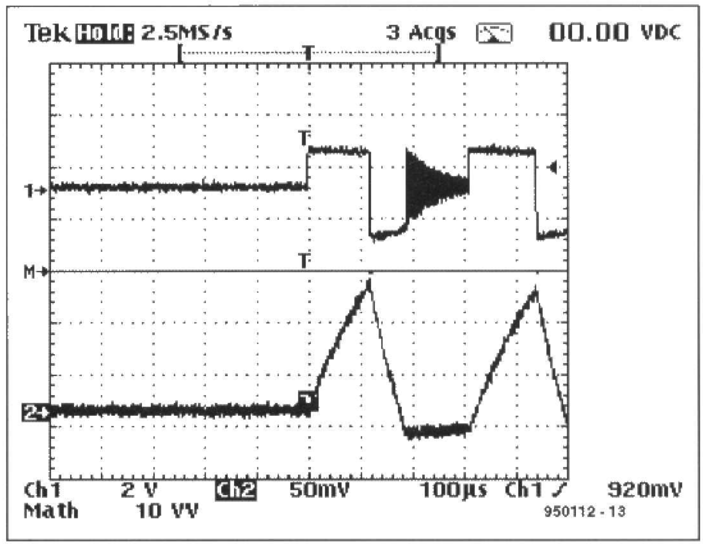


Fig. 3. This dual-trace oscillogram shows the voltage across the inductor and the LED (upper trace) and the current through the inductor.

COMPONENTS LIST

Resistors:
R1,R4,R5,R8 = 10kΩ
R2,R6,R7 = 100kΩ
R3 = 470kΩ
R9 = 1kΩ

Capacitors:
C1,C2 = 470nF
C3 = 2nF2
C4 = 1nF5
C5 = 10µF 63V radial

Inductors:
L1 = 5.6mH (Toko) or 4.7 mH/90mA (Siemens type B82144A2475J)

Semiconductors:
D1 = 1N4148
D2 = ultra-bright LED, e.g., Sharp GL5UR3K
T1-T4 = BC550C
T5 = BC560C

Miscellaneous:
AA size battery holder.
PCB type 950115-1 (see page 70).

soon as the transistor starts to conduct, the voltage across the inductor rises to the supply voltage level. As indicated by the lower trace, the current through the inductor rises to about 60 mA in a short time. A higher current is not allowed because it would cause the LED to be operated outside its maximum electrical specifications. As soon as the transistor is switched off, the voltage across the inductor reverses and becomes the forward operating voltage of the LED. The current through the LED and the inductor drops gradually until the LED goes out. When the LED current has dropped to nought, the inductor circuit is not damped anymore, and a spurious oscillation occurs. This oscillation, a 'ringing' effect, is indicated by the small black triangle in the oscillogram. It decays slowly.

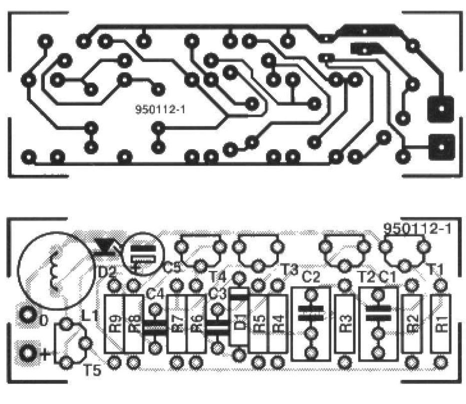


Fig. 4. Copper track layout and component mounting plan of the printed circuit board designed for the jogging LED (board available ready-made, see page 70).

Practical matters

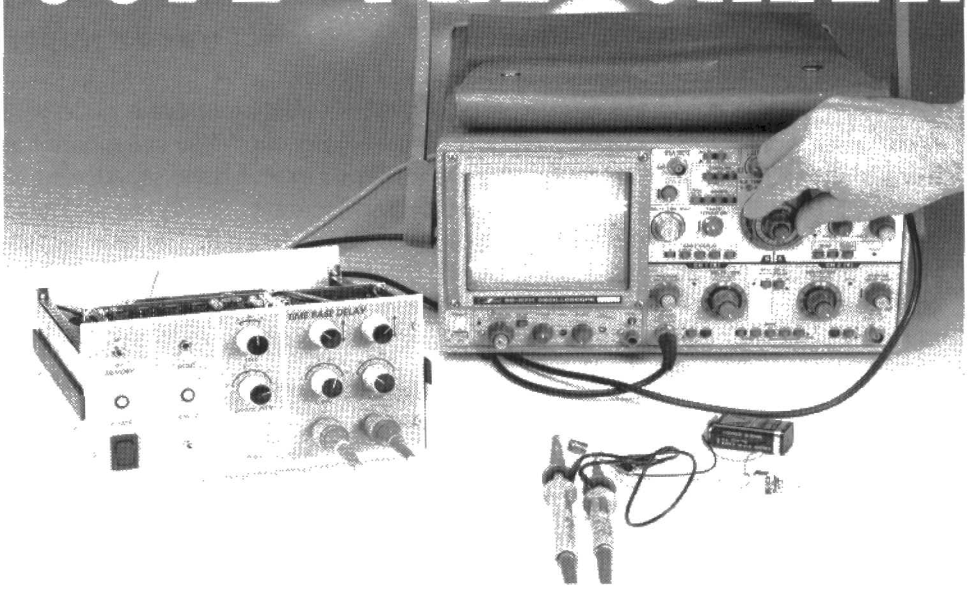
The extremely compact printed circuit board designed for the circuit is shown in **Fig. 4**. The size of the unit (including the battery) allows it to be attached easily to your arm using a strap, a clip or a rubber band.

Start the construction by fitting the parts that make up the multivibrator around T_1 and T_2. Connect a multimeter to one of the collectors, and check if the oscillator works. Strange as it may appear to beginners, correct operation is indicated by an unsteady level. A steady level of 0 V or the supply voltage means that the circuit has a fault. Current consumption should be about 0.15 mA. Next, build the second part, consisting of the oscillator around T_3 and T_4, and check its operation with the aid of your multimeter. Current consumption should have risen to about 0.35 mA at this stage. Then fit transistor T_5, the inductor and the red LED. Do not switch on the circuit without the LED fitted. If you do, transistor T_5 may be destroyed by the back-e.m.f. generated by L_1 (remember, the LED functions not only as a visual indicator but also as a back-e.m.f. suppressor). Now, if everything has been built correctly, the LED will start flashing when you fit the battery. Current consumption measured on the prototype was about 1.15 mA. A normal alkaline dry battery (AA, penlight size) should have enough energy for about 2 months of operation. As the battery voltage drops, the brightness of the LED and the current consumption drop proportionally.

Once all parts are fitted, and the circuit works, fit the battery holder to the copper side of the board. This is may be done with blu-tak, thermal glue or silicone compound glue. Next, mount the unit into a short length of PVC tube. Secure a strap or a rubber band to the tube so that it can be attached to your arm. The red light should, of course, remain visible through a small window. Incidentally, a good quality LED clip may also be used to make the unit water-resistant.

That completes the construction of the jogging LED. A final word of advice: even if you use the jogging LED, be extremely careful while you are running out there in the dark. If at all possible, avoid busy roads. (950112)

OSCILLOSCOPE PRESCALER



Design by H. Bonekamp

An analogue oscilloscope that is used for measuring slow processes has the drawback that the test time per scale division is relatively short. The prescaler described enables the time base to be set between 1 second and 30 hours, which should prove adequate for most measurements.

The specification of oscilloscopes normally states the maximum available bandwidth. Nowadays, this is at least 20 MHz, but usually it is 100 MHz or more. With the advent of digital oscilloscopes, the lower range is also extended appreciably. Analogue oscilloscopes, however, are seriously restricted as far as (very) low frequencies are concerned. True, any oscilloscope, digital or analogue, can be used for measuring direct voltage and current, but, owing to lack of a visual memory, the displaying of a process on an analogue type normally ends at a few hertzs. Consequently, the displaying of a process that takes hours, such as the charging of a battery, can only be done on a digital oscilloscope. Regrettably, even nowadays these types of oscilloscope are fairly expensive. Fortunately, the present prescaler makes it possible to use an analogue oscilloscope for (very) slow processes.

Design considerations

To some extent, the prescaler is a digital oscilloscope without the display section. Thus, it contains a dedicated time base, two input stages with a variable attenuator, an analogue-to-digital converter (ADC), a digital-to-analogue converter (DAC), and a visual memory—see **Fig. 1**. The outputs of the circuit are an analogue voltage that is applied to the *y*-input of the oscilloscope and a trigger signal which is linked to the external-trigger input of the oscilloscope. This enables two channels to be displayed simultaneously.

The time base provided the clock which controls the entire circuit. Samples are taken at the clock rate (2×512 pulses/second). The clock also starts the ADC.

The time-base divider determines which samples are to be stored. At the highest rate, 512 samples per channel are taken per second, but at the lowest rate it takes 30 hours for 512 samples to be taken. All samples are stored; the address counter ensures their correct location. Reading the data is enabled by the time base.

The data to be stored is provided by the ADC, to which the signal from the two input stages is applied alternately. The alternation of the two stages (and thus, the channels) is effected by a switching signal.

When the data are displayed on the oscilloscope, the DAC converts the stored data into an analogue signal. The relevant circuit contains a multiplexer that enables two traces to be shown on a single-channel oscilloscope. The location of the traces on the screen is set with two position controls.

The trigger circuit provides the signal that synchronizes the oscilloscope and the prescaler.

Basic design

The prescaler is based on an address counter and a time base counter, which are represented by the two discs in **Fig. 2**. Although in reality both counters can count up to 512, for clarity's sake they are allocated only eight positions in the illustration. At the onset (Fig. 2a), the counters are synchronous. When a sample has been stored, however, they shift one position with respect to each other (Fig. 2b). On the oscilloscope screen this is shown by the sample shifting one position to the left. After eight samples, the starting position will be reached again. In reality, there are 512 positions, that is, the screen displays 512 samples side by side. It is always possible to scroll through the signal by adjusting the time base. Since the counters shift one position per sample, the latest sample will always be at the right and the oldest at the left of the screen. When the maximum number of samples has been stored, the counters are synchronous again and the oldest sample is deleted. And so the process continues.

Technical data

Converter	
Input impedance	1 MΩ
Attenuator	5, 2, 1, 0.5, 0.2, 0.1 V/div
Resolution	8 bits
Number of channels	2×2
Sampling size	512 bytes
Time base	1 s, 1 min, 1 hr
Extension factor	×1, ×2, ×5, ×10, ×15, ×30
Oscilloscope setting	
Sensitivity	0.5 V/div
Time base	50 µs/div

Circuit description

The circuit diagram of the prescaler is given in **Fig. 3** and that of the power supply in **Fig. 5**.

The heart of the circuit is generator IC_{1a}, which provides a signal of 4.194304 MHz (that is, 2^{22} Hz). This clock frequency has been chosen because it is a whole multiple (×8192) of 512.

Scaling down the clock signal by 2 in IC_{2a} provides a

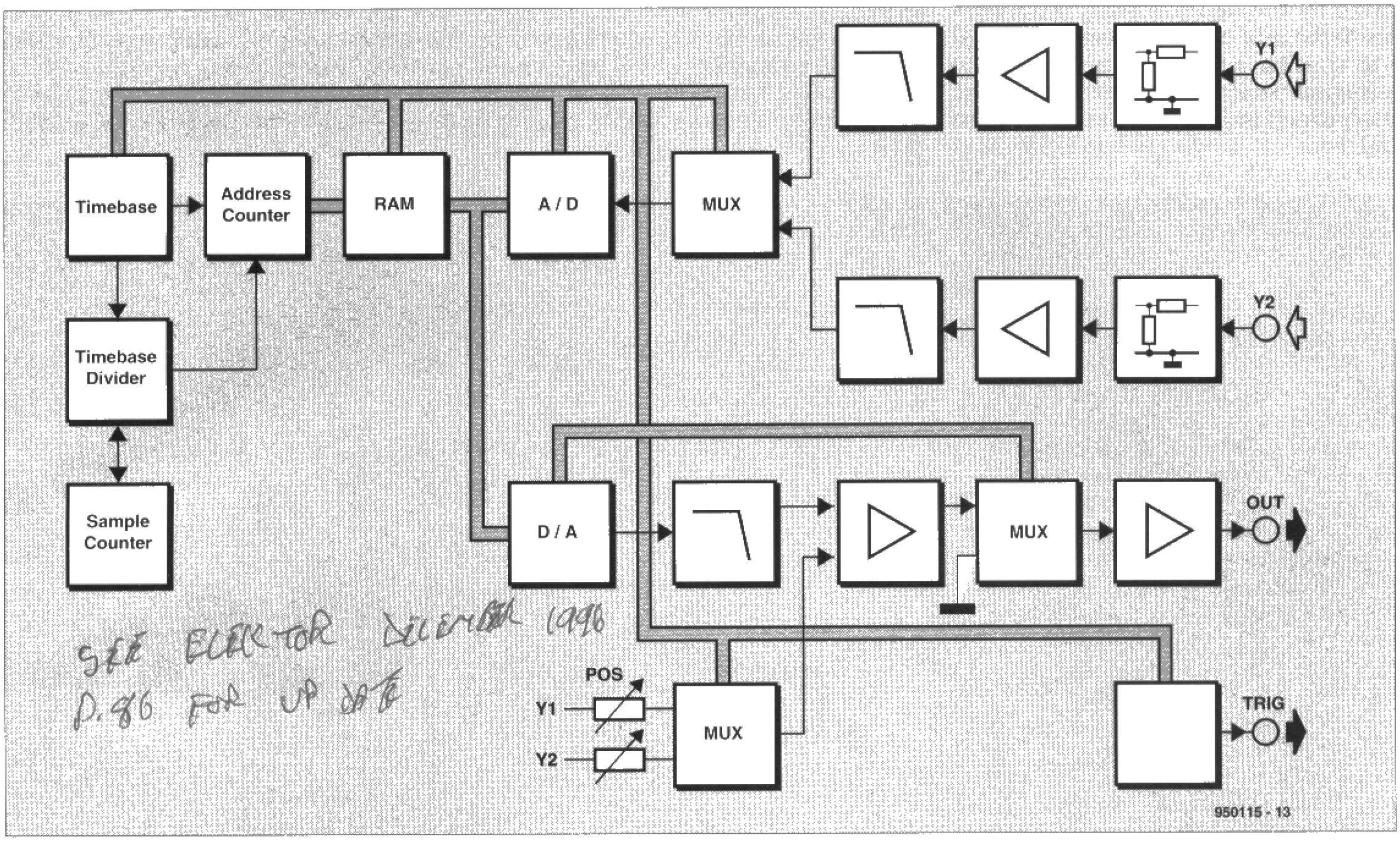


Fig. 1. The basic setup of the oscilloscope prescaler.

rectangular signal of 2.097152 MHz. This scaler would not have been needed if a 2.097152 MHz crystal had been used: unfortunately, this is available only to special order, which is costly.

The clock signal controls the time base formed by IC_6, a 12-bit counter, which provides signals T_0–T_{10}. Signals T_0–T_8 are applied, together with the inverted clock signal and signal NT_9, to NAND gate IC_9. If these signals are logic high,the output of IC_9 becomes low for a brief period. This output is inverted in IC_{1d} to become the WR signal with which the ADC (IC_{19}) applies its digital output data to the bus.

The output of IC_{1d} is also used for generating the WE-pulse for the RAM. This arrangement is necessary since the entire circuit operates asynchronously. The combined signals ensure that the control signals are stable. A synchronous arrangement requires many more components.

Signal T_9 is used as a trigger and to control multiplexer IC_{20}. In inverted form, NT_9, it is used to enable the DAC (IC_{19}) and to trigger the ADC (IC_{18}), and also to trigger the oscilloscope. See also the timing diagram in **Fig. 4**.

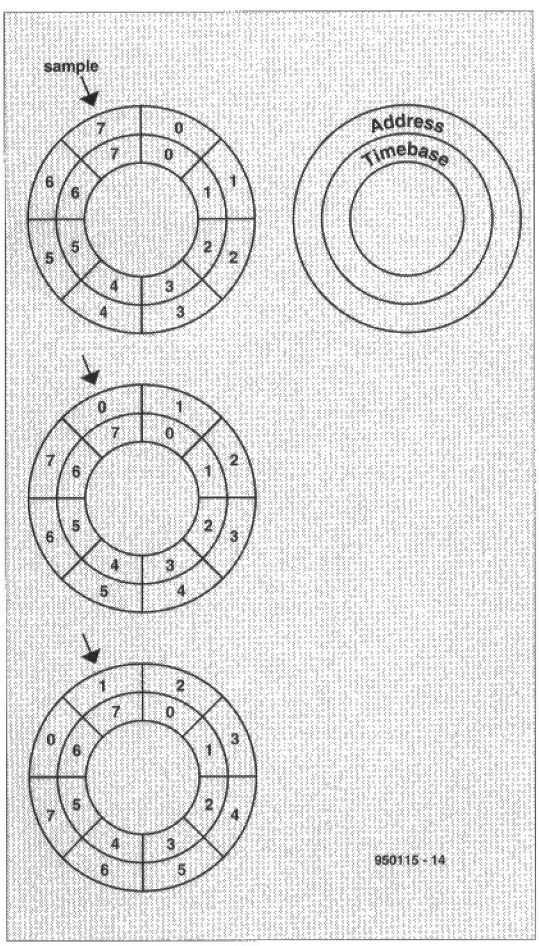


Fig. 2. Simplified representation of the interaction between address counter and the time base counter.

Signal T_{10} is used to control multiplexer IC_{20}, the block selection of memory IC_{13}, and as input signal to the time base divider. It also plays a role in the timing of the reset signal.

Addressing memory IC_{13} is effected by address counter IC_5. The content of this counter is increased by 1 at every clock pulse (CLK). Each channel is sampled 512 times a second. A sample is stored only if an additional clock pulse (ECP) is generated, which depends on the setting of the time base. This pulse also effects the shift between the time base counter and the address counter as discussed earlier.

The ECP is generated by a discrete differentiator, T_1; the pulse duration is 50 ns. This somewhat unusual arrangement ensures that the ECP is independent of the setting of the time base. That setting determines whether a rectangular signal or a spike pulse is applied to the differentiator.

The HOLD switch, S_4, ensures that writing to the memory can be stopped. When it is closed, no ECP can be generated and the screen image is frozen.

Similarly, if SINGLE switch S_3 is closed, writing to the memory stops as soon as output Q_9 of IC_{14} becomes high. This situation is indi-

cated by the lighting of D_2. All memory locations contain a sample after 512 ECPs have been generated.

Signal M on the address bus of IC_{13}, which is generated with MEMORY switch S_2, enables a second memory bank to be used. Since clock signal T_{10} reserves memories for two separate channels, this arrangement means that the total memory is split into four blocks, each of which can hold 512 bytes. The output enable signal for the memory is signal NT_9 mentioned earlier, while the write enable signal, WE, is provided by network IC_{8a}, IC_{8b}, and

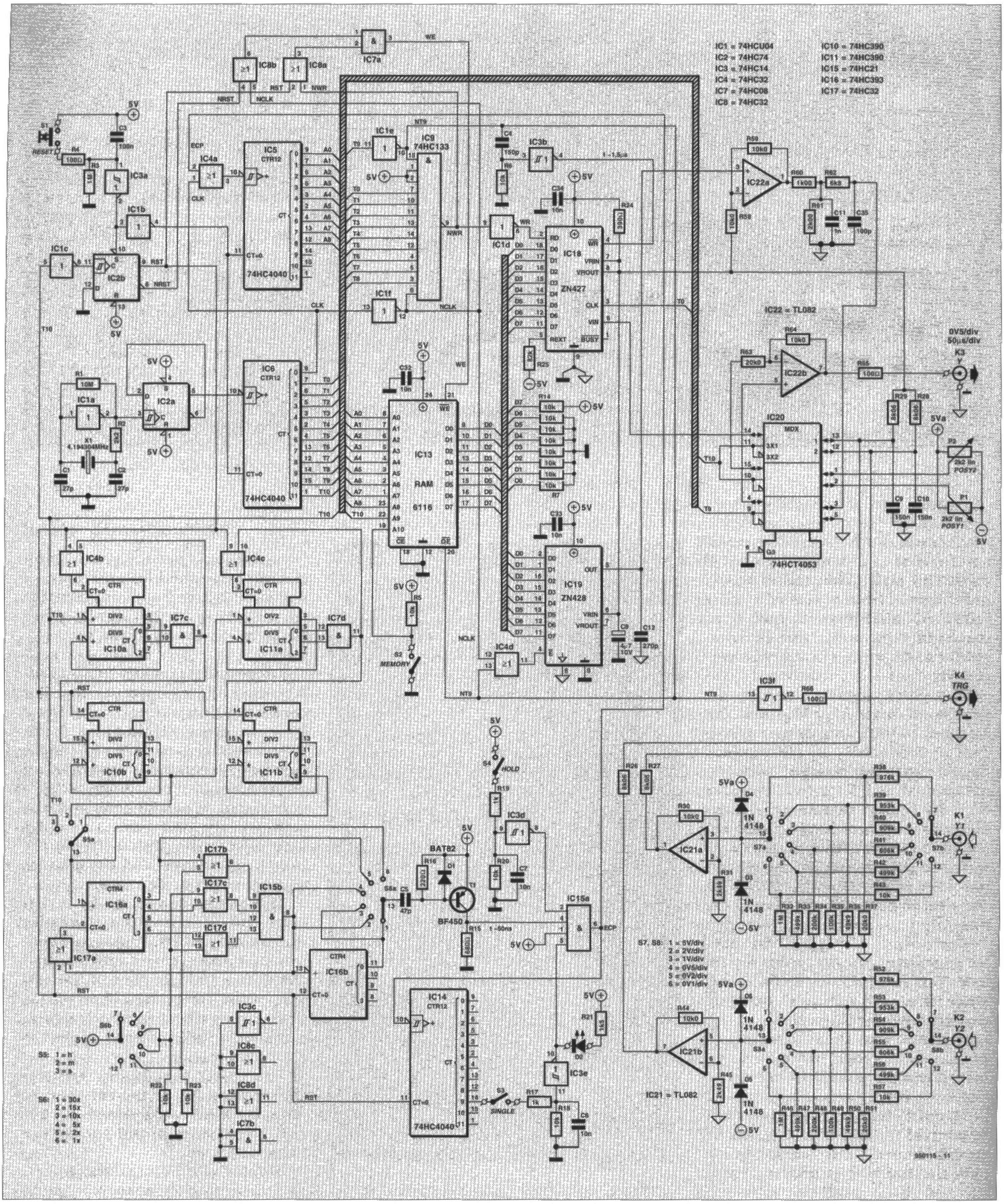


Fig. 3. The circuit of the oscilloscope prescaler consists of a digital and an analogue section.

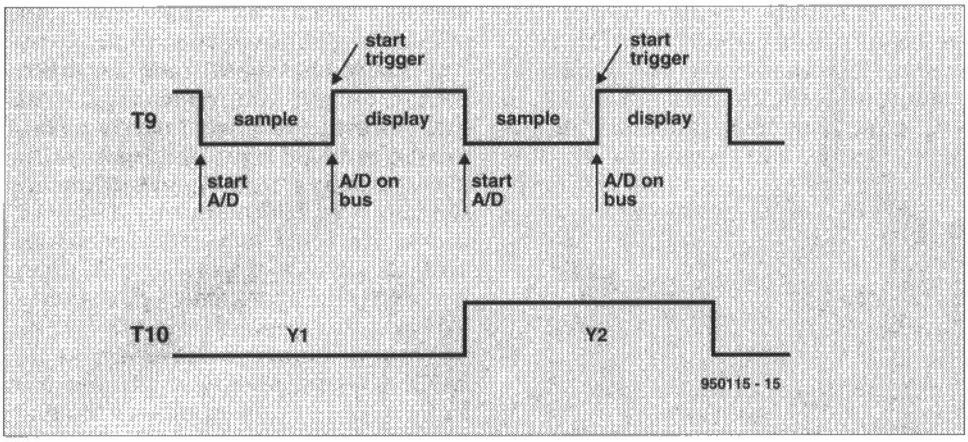


Fig. 4. Timing diagram of signals T_9 and T_{10}, which play a significant role in the manner in which sampling is effected.

AND gate IC_{7a}.

The time base signal is scaled down by the circuit based on IC_{4b}, IC_{17b}, IC_{10}, IC_{11}, IC_{15b}, IC_{16} and IC_{17}. The operation of this network depends on the setting of switch S_5, which arranges the scaling factor to be 1:1, 1:60, or 1:3600. Switch S_6 arranges a further scaling of 1:1, 1:2, 1:5, 1:10, 1:15, or 1:30.

To ensure that after the prescaler has been switched on the RAM is full (80_H), a special reset routine is carried out which arranges for the sequential writing of 1024 (2^{10}) times 80_H to the memory. The resistors connected to inputs D_0–D_7 of the RAM ensure that during this writing the level at data inputs D_0–D_6 is low and that at D_7 is high. The figure 80_H is used, because this is half-way between 00_H and FF_H and thus represents a signal corresponding to 0 V.

AD converter IC_{18} needs nine clock pulses for the conversion and starts this as soon as signal NT_9 is high and is entered on to the bus. The result of the conversion is put on to the bus just before the end of the period during which NT_9 is high: signals T_0–T_8 are then also still high.

At the moment the addresses have stabilized, the highest address is selected, whereupon the circuit is in the conversion mode (NT_9 = 1). Since the ADC has a disable time of 180 ns, the requirement of the RAM that the data must be held stable during the hold time (after the WE pulse has been given) is met.

The reset process is divided into two phases. The first ensures the resetting of the clock generator, the address counter and the time base counter. The second encompasses a complete time base cycle to reset the time base scaling circuits. This procedure is vital, because after a reset the counters must be in identical positions. If this were not the case, time differences might occur between the memory banks storing the channel data.

Also, the second phase arranges for the memory content to be erased. Note that this applies only to the selected memory bank, M_1 or M_2. When upon a power-up reset the other memory bank is enabled, an undefined images appears on the screen in the first instance.

It may be noted that the clock oscillator can not be adjusted. This is a deliberate omission, because the accuracy is already 100 ppm or better, which is more than sufficient for normal applications. Where a higher accuracy is desired, C_1 may be replaced by a 40 pF trimmer.

The analogue part of the circuit contains the input attenuators, the output stages, and the power supply.

For each channel, a 6-step attenuator is provided. Since very-low-frequency signals are to be measured, it is not necessary to make the attenuator independent of the frequency. This keeps the input stages relatively simple. Overvoltage protection is provided by diodes D_3–D_6. The input impedance is 1 MΩ. In the most sensitive position, the signal is not attenuated (although the protection circuits do cause a certain loss of signal).

After the input stages, the signal is amplified to the required level of 4 V_{pp}.

Subsequently, the d.c. level of the input signals is shifted with the aid of the reference voltage of the ADC and resistors R_{26}–R_{29}, so that the base level is half-way the measurement range. The summing circuit arranges for the signal levels to be halved.

The output stage starts at pin 5 of

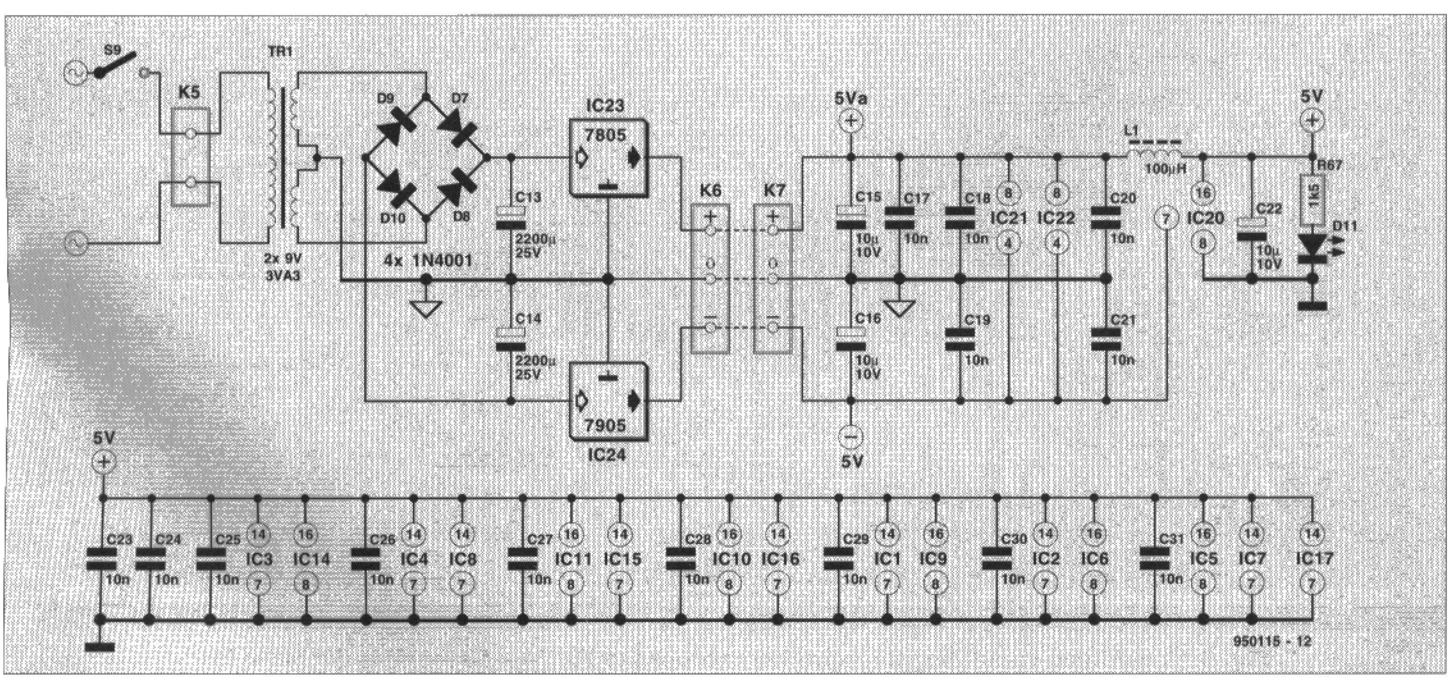


Fig. 5. The design of the power supply ensures good decoupling between the digital and analogue sections.

the DAC, IC_{19}. The output impedance, in conjunction with the reactance of C_{12}, forms the first section of a third-order filter, the remainder of which is after IC_{22a}. This low-pass filter and the oversampling used (×10) ensure a clean output signal.

Unfortunately, the filter is not able to eradicate a small flaw of IC_{19}, which, like other DACs, has a spike at its output at the transition from $7F_H$ to 80_H. Exactly at this transition, all bits must switch, but, owing to the tiny timing errors in the IC, this will never occur at exactly the same time. This results in glitches at the output.

Finally, the signal reaches multiplexer/output amplifier IC_{22b}. This stage provides a mass reference point for the extreme right-hand part of the screen image. This ensures that any

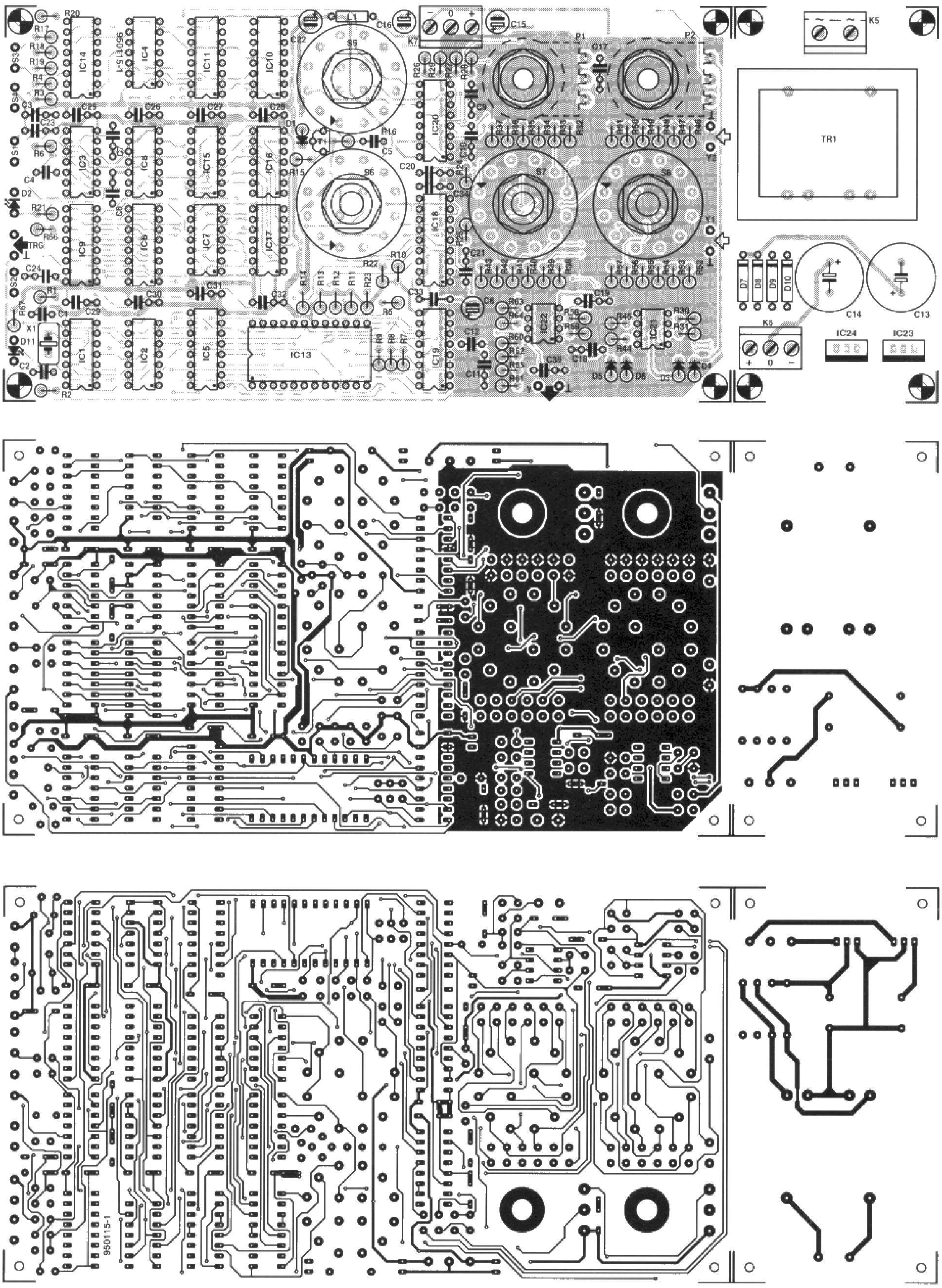


Fig. 6. The printed-circuit board (shown here reduced to 70.7% = A3 → A4) is double-sided. Note that the analogue section has an earth plane to minimize interference.

non-relevant in the DAC at that moment is not passed to the output. The reference point is located at the zero line on the screen.

The prescaler requires a symmetrical power supply: its diagram is shown in **Fig. 4**. The secondary voltages of Tr_1 are rectified by a discrete bridge rectifier and then applied to regulators IC_{23} and IC_{24} to produce symmetrical ±5 V power lines. Diode D_{11} serves as on/off indicator. Inductor L_1 provides additional decoupling between the digital and analogue sections of the prescaler.

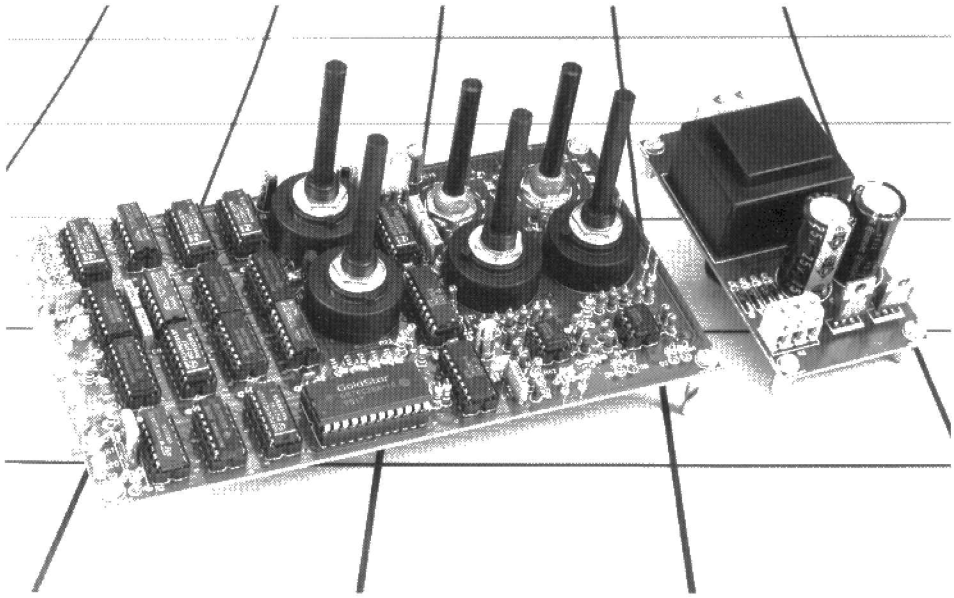


Fig. 7. The completed prototype prescaler board and power supply.

Construction

The prescaler is most useful if it is constructed as a stand-alone unit, and this aspect has been taken into account in the design of the printed-circuit board—see **Fig. 6**. A suggested front panel layout for the enclosure is given in **Fig. 8**.

Before any work is done on the PCB, cut off the section for the power supply: where to cut is clearly indicated. Populating the two boards should not present any undue difficulties if frequent reference is made to Fig. 6.

After all components have been soldered into place (all resistors upright, which causes some work in bending their leads as relevant), it is advisable to check with a multimeter whether the required ±5 V supply is present at K_6. Since IC_{24} provides the correct output only when it is loaded, it is necessary during this test to connect a 2.2 kΩ resistor across the relevant pins of K_6. Note the earth plane at the component side of the motherboard: this prevents cross-talk between channels and induction of spurious pulses.

Circuits IC_{18}, IC_{19} and IC_{20} link the digital and analogue sections.

It is advisable to use sockets for all ICs.

Potentiometers P_1 and P_2 must be placed at the track side of the board. Their terminals should be bent so that they fit exactly in the relevant holes in the board.

Stops should be set as relevant on the rotary switches with the aid of the rings supplied with the switches

Connections at the edges of the board are best made via solder pins; this ensures that they remain easily accessible after the board has been fitted in the chosen enclosure.

Testing

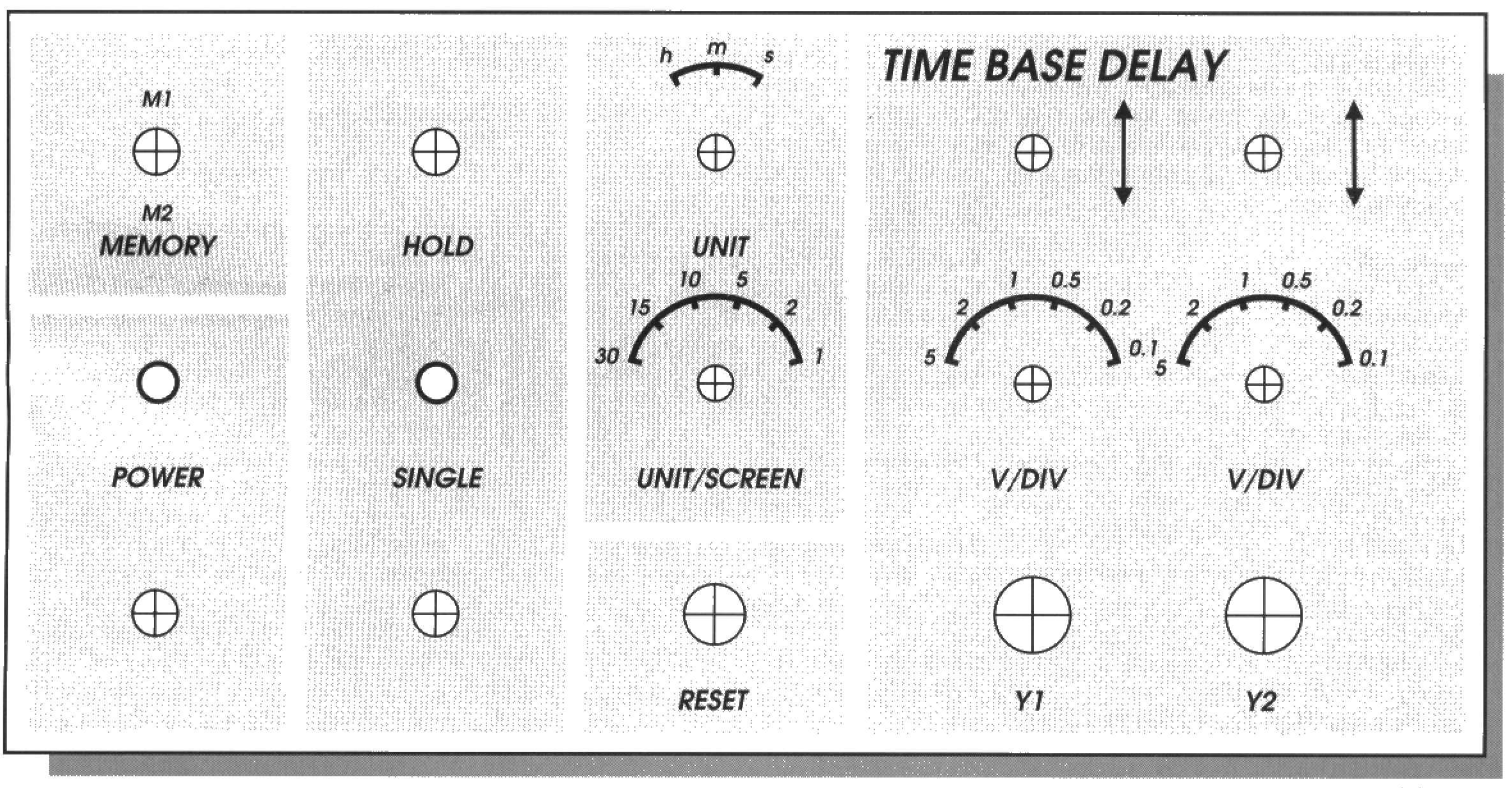


Fig. 8. Suggested front panel layout of the oscilloscope prescaler (scale 1:1).

Before the boards are fitted in the enclosure, it is advisable to test its operation. For this purpose, the switches can be soldered temporarily to the solder pins at the left-hand side of the board. If the relevant functions need not be tested, the switches can, at stage, be omitted, of course.

Set the switches to the appropriate positions and link the prescaler to the oscilloscope. The output voltage of a variable mains power supply may be used as the signal source. Set the oscilloscope to positions 0.5 V/div and 50 μs/div, and to external triggering. If all is well, the screen should show two lines. The position of these can be altered with P_1 and P_2. If all this operates correctly, the voltage source can be switched on. Any changes in the output level of the variable power supply should be clearly discernible on the oscilloscope. If all this is well, the boards can be fitted in the case.

The enclosure may be finished with the suggested front panel shown in **Fig. 8**. This illustration (or, rather, a photocopy of it) may also serve as a template for drilling the holes in the actual front panel of the enclosure.

The motherboard is fitted on 15–20 mm long spacers at the back of the front panel with four M3 screws (with sunken head). When this is done, the home-made front panel foil can be glued on to the panel.

Subsequently, the switches, LEDs and connectors can be fitted on to the enclosure.and wired to the motherboard.

The power supply is fitted on 10–15 mm spacers and fitted to the rear panel with M3 screws (with sunken head).

Finally, a mains entry and two BNC sockets must be fitted to the rear panel. The BNC sockets are used for making the *y* and TRIG connections to the oscilloscope.

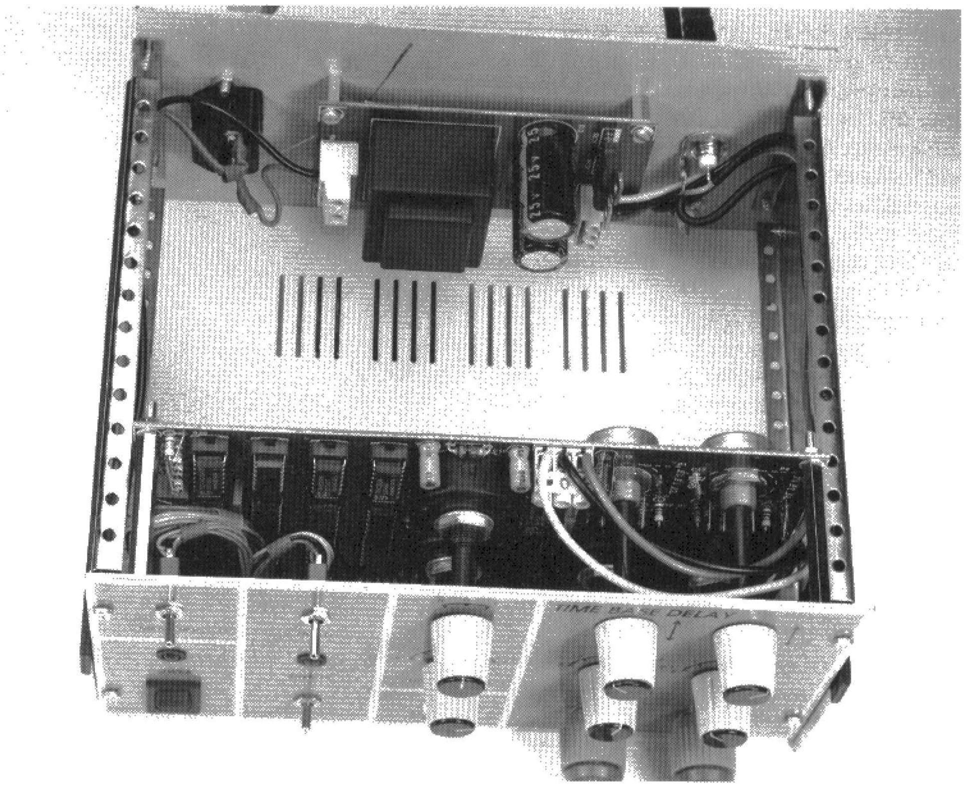


Fig. 9. Completed prototype prescaler in enclosure with top panel removed.

Parts list

Resistors:
R_1 = 10 mΩ
R_2 = 2.2 kΩ
R_3, R_{32}, R_{46} = 1 MΩ
R_4, R_{65}, R_{66} = 100 Ω
R_5, R_6, R_7–R_{14}, R_{18}, R_{20}, R_{22}, R_{23}, R_{43}, R_{57} = 10 kΩ
R_{15} = 680 Ω
R_{16} = 220 Ω
R_{17}, R_{19} = 1 kΩ
R_{21}, R_{67} = 1.5 kΩ
R_{24} = 390 Ω
R_{25} = 82 kΩ
R_{26}–R_{29} = 8.06 kΩ, 1%
R_{30}, R_{44}, R_{58}, R_{59}, R_{64} = 10.0 kΩ, 1%
R_{31}, R_{45} = 2.49 kΩ, 1%
R_{33}, R_{42}, R_{47}, R_{56} = 499 kΩ, 1%
R_{34}, R_{48} = 200 kΩ, 1%
R_{35}, R_{49} = 100 kΩ, 1%
R_{36}, R_{50} = 49.9 kΩ, 1%
R_{37}, R_{51} = 20.0 kΩ, 1%
R_{38}, R_{52} = 976 kΩ, 1%
R_{39}, R_{53} = 953 kΩ, 1%
R_{40}, R_{54} = 909 kΩ, 1%
R_{41}, R_{55} = 806 kΩ, 1%
R_{60} = 1.00 kΩ, 1%
R_{61} = 2.00 kΩ, 1%
R_{62} = 6.8 kΩ
R_{63} = 20.0 kΩ, 1%
P_1, P_2 = 2.2 kΩ linear potentiometer

Capacitors:
C_1, C_2 = 27 pF, ceramic
C_3 = 100 nF, polypropylene
C_4 = 150 pF, ceramic
C_5 = 47 pF, ceramic
C_6, C_7 = 10 nF, polypropylene
C_{17}–C_{21}, C_{23}–C_{34} = 10 nF
C_8 = 4.7 μF, 10 V, radial
C_9, C_{10} = 150 nF, polypropylene
C_{11} = 1 nF, polypropylene
C_{12} = 270 pF, ceramic
C_{13}, C_{14} = 2200 μF, 25 V, radial
C_{15}, C_{16}, C_{22} = 10 μF, 10 V, radial
C_{35} = 100 pF, ceramic

Inductors:
L_1 = 100 μH

Semiconductors:
D_1 = BAT82
D_2, D_{11} = LED, high efficiency
D_3–D_6 = 1N4148
D_7–D_{10} = 1N4001
T_1 = BF450

Integrated circuits:
IC_1 = 74HCU04
IC_2 = 74HC74
IC_3 = 74HC14
IC_4, IC_8, IC_{17} = 74HC32
IC_5, IC_6, IC_{14} = 74HC4040
IC_7 = 74HC08
IC_9 = 74HC133
IC_{10}, IC_{11} = 74HC390
IC_{13} = 6116
IC_{15} = 74HC21
IC_{16} = 74HC393
IC_{18} = ZN427E
IC_{19} = ZN428E
IC_{20} = 74HCT4053
IC_{21}, IC_{22} = TL082
IC_{23} = 7805
IC_{24} = 7905

Miscellaneous:
K_1–K_4 = BNC socket
K_5 = 2-way terminal block, pitch 7.5 mm
K_6, K_7 = 2-way terminal block, pitch 5 mm
S_1 = push button switch
S_2–S_4 = mini toggle switch with make contact
S_5 = rotary switch, 4-pole, 3 positions
S_6–S_8 = rotary switch, 2-pole, 6 positions
S_9 = single-pole mains switch
X_1 = crystal, 4.194304 MHz
Tr_1 = mains transformer, 2×9 V, 3.3 A secondaries, e.g. Velleman 2090038M (Maplin)
Enclosure
PCB Order No. 950115 (see page 70)

[950115]

'MATCHBOX' BASIC COMPUTER (PART 2)

Following the description of the computer's hardware in last month's introductory instalment, buckle yourself for a fast introduction to the software side of things. To start with, we describe a number of programming utilities which are integrated in the Matchbox software. Then follows a brief introduction to some elementary aspects of the MatchBox BASIC programming language.

Software by Dr. M. Ohsmann

A simple programming language was developed for the purpose of programming the MatchBox BASIC computer. This language is a blend of BASIC and Pascal. Special attention was given to the ability to control the various hardware extensions. Before discussing the different elements of the programming language, we show you how to load and run your first program on the MatchBox.

Your first program

Provided the first hardware test described last month was successful, you are ready to download the first MatchBox program to the MatchBox, and run it. This is very simple indeed. First, create a new directory with a suitable name, for instance, C:\MATCHBOX, on your PC's hard disk. Next, copy all files on diskette 956009-1 into that subdirectory, and store the diskette in a safe place.

On the PC, go to the MatchBox subdirectory, and type

```
MBC PROG1 -COM2 (return)
```

If you are using a different communication port, for instance, COM1, type the proper name instead of 'COM2' in the above command line. A lot happens, and very quickly too, after you have typed the above command. First, the MatchBox compiler, MBC, launches. It converts the source program, PROG1.MBL, loaded from disk, into an internal, intermediate language format, which is stored into the PC's memory. Next, the MBC starts a V24 (RS232) terminal simulator which allows the PC to communicate with the MatchBox. The MatchBox compiler also generates a listing (PROG1.LST), which is illustrtrated in **Listing 1**.

Now check that the download jumper is fitted on the MatchBox board. Switch on the MatchBox, and press the Reset button. This causes the MatchBox to start up, and send a text to the PC via the serial interface. If everything is all right so far, the terminal program which runs on the PC will display this text. Now you are ready to download the program. Simply type CTRL-D (i.e., press CONTROL and 'D' keys at the same time). After the download operation, the PC returns the message 'DOWNLOAD OK!'. If you press the Return key, the MatchBox will return the text MBl>>. Next, type 'x' (for 'eXecute') to start the program which you have just loaded into the EEPROM. All this program does is send the text 'The first program' to your PC. Does it work? Congratulations!

Now remove the download jumper from the pin header on the MatchBox board. Try pressing the reset key, or switching the MatchBox power supply off and on again. In both cases, the above little program should run again.

Your next goal should be to make life with the MatchBox as easy as possible. Start by reading the INSTALL.DOC file on disk. This will tell you how to complete the menu program, MB, with the necessary data and file pointers. Once customized to your liking, the MB menu program is simple to use, and helps to reduce the number of keys that has to be pressed to complete a download operation to an absolute minimum. At this stage, you are ready to have a first go at writing your own programs. Alternatively, start by modifying PROG1.MBL. For instance, change the text a little, or add further PRINT statements. You may also want to have a look at some of the example programs (extension .MBL) on the disk. However, if you

Listing 1

```
The MATCHBOX compiler V0.1 1.7.1994 (c. M.Ohsmann) INPUT-FILE: PROG1.MBL
  1 0002 :; PROG1.MBL    ; a few lines comment
  2 0002 :; subject:    A first program
  3 0002 :;
  4 0002 :RESOURCE IIC-EEPROM 0100H  BYTES @ 05000H ; declare attached
EEPROM
  5 0002 :PRINT('The first program')      ; send a text
  6 0015 :STOP                            ; stop execution
  7 0016 :END                             ; end of source code
compilation complete
AVAILABLE AREAS ARE:
free          EEPROM  at [     1] 0000H..00FFH length 0100H
boot eprom has been located...at index     1 length is :0100H
code allocated with idx=     1 0H..0015H
code starts at=000AH
ALLOCATION-TABLE:
--------------------------------------------------
RESTAB allocation
      restab[     0]=rrIICEP.5
      restab[     1]=rrIICEP.5
      restab[     2]=rrDUMMY
      restab[     3]=rrDUMMY
      restab[     4]=rrDUMMY
      restab[     5]=rrDUMMY
      restab[     6]=rrDUMMY
      restab[     7]=rrDUMMY
AVAILABLE AREAS ARE:
free          EEPROM  at [     1] 0020H..00FFH length 00E0H
initialized EEPROM  at [     1] 0000H..001FH length 0020H
```

want to work systematically, it is recommended to first read on about the actual abilities of the MatchBox, and then make a flying start with the example programs.

A MatchBox program consists of individual lines. There is only one command in each line. It is not possible to cram more commands into one line. However, lines may contain labels (see below) and comment. There are no line numbers, and the programs may be produced with any word processor capable of outputting text in straight ASCII format. The MatchBox language is case sensitive. Keywords are usually written in capitals. Some designators (labels, variable names, and so on) may be written in capitals or lower case characters. Note, however, that the program still sees the difference between capitals and lower case characters. Thus, 'COUNTER' and 'Counter' are two different variables.

First commands

At the end of each MatchBox program the compiler should find the END directive. Any text which follows the END directive is simply ignored because the compiler has ended its job. If you want the MatchBox to halt the execution of a program, and return to interactive mode, that may be achieved by inserting the STOP command. The DELAY instruction allows you to create delay periods. Assuming that a 12 MHz crystal is used, the line

```
DELAY(100)
```

causes a delay of 100 times 10 ms, or one second.

Labels

Any line of a MatchBox program may start with a label. A label serves as a reference for GOTO commands. Subroutines, too, are identified by labels. Labels should be terminated with a colon (:). An example of a line containing a label is

```
START: PRINT('HERE GOES')
```

The ability to use labels eliminates the need of those awkward line numbers which were required in early dialects of BASIC.

GOTO

The GOTO command is still alive and well in spite of many misgivings. Provided it is use with care, the GOTO command is very useful, and does not necessarily cause unstructured programming. In the MatchBox, the command

```
GOTO label
```

causes the program to jump to the location indicated by 'label'. It goes without saying that such a GOTO command easily leads to 'badly written' code. None the less, it offers a simple, effective means to do lot of programming drudgery in a simple and uncluttered way.

Comment

As every programmer should know, comment serves to help yourself (and others) understand and remember what a particular line or program section does. Comment starts after a semicolon (;), and is not interpreted in any way by the MBC. A line containing a label, a command and some comment may look like this:

```
PROGRAM end: STOP ; this is where
                    the program
                    halts
```

Never skimp on comment, because it helps to keep your programs understandable, also after a couple of weeks.

An example

Let's tackle the first 'commented' example, which shows how the MatchBox may be used to make a LED flash. To keep the hardware as simple as possible, the LED is connected to the RS232 line after downloading and running the relevant demonstration program. The LED may be connected either way around between pins 2 and 5 of the 9-way sub-D socket (**Fig. 1**), and should start to flash if you run the program shown in **Listing 2**.

This program may be found on disk as 'PROG2.MBL', and may be edited by typing MB PROG2.

Control structures

A programming language offers control structures to determine the course of the program depending on the outcome of certain tests. The best known construction in this respect is IF... THEN...ELSE, which is also understood by the MatchBox. It may be programmed in one of two versions:

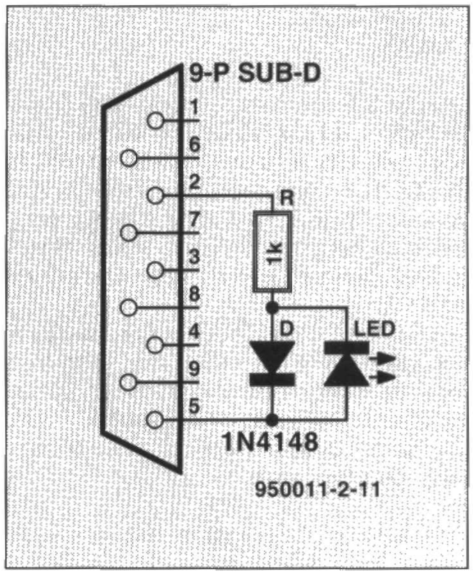


Fig. 1. Have fun by connecting this LED/resistor combination to the RS232 lines and make the LED flash by means of a simple program run on the MatchBox computer.

```
; version 1
IF test THEN
  then_statements ; are executed
when the test returns TRUE
  ENDIF

; version 2
IF test THEN
  then_statements ; are executed
when the test returns TRUE
ELSE
  else_statements ; are executed
when the test returns FALSE
ENDIF
```

Any number of lines may be contained between IF, THEN and ENDIF.
The other control structures recognized by the MatchBox are REPEAT and the WHILE loop. For example:

```
REPEAT
  statements
UNTIL test
;
WHILE test DO
```

Listing 2

```
; PROG2.MBL
; subject: flashing light, LED at RS232 Pin 2 and Pin 5 of 9-Pin DSUB
;
  RESOURCE IIC-EEPROM 0100H BYTES @ 05000H ; PCF8582 EEPROM
AndON:                                     ; a label
  P3.1:=0                                  ; TxD set to +10 Volt
  DELAY(10)                                ; 100 ms delay
  P3.1:=1                                  ; TxD set to -10 Volt
  DELAY(40)                                ; 400 ms delay
  GOTO AndON                               ; start again
END                                        ; end of source code
```

```
  statements
  WHEND
```

Commands enclosed within the lines REPEAT and UNTIL are repeated until 'test' returns a 'true' indication. With the WHILE command, the commands between WHILE and WHEND are executed as long as the 'test', which is executed before each loop iteration, yields 'true'.

The MatchBox BASIC language does not offer the FOR statement because that is easily mimicked by suitably arranged REPEAT and WHILE commands in combination with a loop iteration counter, as in

```
; like this in standard BASIC
;  FOR K:=1 TO 10 DO
;  for_statements
; NEXT K
;
; MatchBox: Replace FOR loop by
WHILE command
K:=1
WHILE K<=10 DO
  for_statements
  K:=K:+1
  WHEND
```

Variables

While programming, it is often required to put values away in temporary storage. Such values may represent numbers, bit patterns, flags, etc. The actual meaning of such a stored value is determined by the programmer. In MatchBox BASIC, values may be stored in so called variables, which are identified by exclusive names, and for which the compiler reserves exclusive memory locations. Variables may be used in two ways. A variable may have its value changed, or it may be assigned a value. In the latter case, the variable is located to the left of the '=' sign ('location'), while the value appears to the right. The MatchBox language has a special feature in this respect because it allows location/value assigning to be used not only for variables, but also for the special function registers (SFRs) of the 8051, which may occur as locations or values.

MatchBox programming allows both 8-bit (type BYTE) and 16-bit (type INTEGER) variables to be used. These variables may be placed in RAM, which is normally done by the compiler, or packed into the EEPROM, if the value needs to be retained after the computer is switched off. A couple of examples showing valid variable declarations:

```
BYTE X          ; a byte is stored
                  in X
BYTE EEPROM Y   ; Y stored as a byte
                  in EEPROM
```

In order to assign the value 10 to variable X (used as a memory location), you simply write

```
X:=10
```

Similarly, to increase variable Y by 5, write

```
Y:=Y+5
```

Note that Y is used as a location to the left of the assignment symbol ':=', while it is a value to the right of it. In this respect, a number is also a value.

As a special feature, variables may also be stored in user-specified address locations in special memory devices. This allows you use, for instance, the 8051's internal RAM. Examples showing how to do this may be found on the courseware disk. It is also possible to define one-dimensional arrays — more about this further on. Variable names may have a length of up to 16 characters.

```
REM a Quick Reference
REM Card listing all
REM MatchBox BASIC
REM command formats,
REM syntax and
REM hardware
REM connexions is
REM included with set
REM 950011-C. This
REM card is also
REM available
REM separately.
REM See page 70.
```

Resources

As already mentioned in the first instalment of this article series, the MatchBox computer may be connected to a number of extensions such as additional EEPROMs and I^{2}C RAMs. Obviously the compiler should be told which of these extensions may be used for program and/or data (variable) storage. This system information is conveyed to the MBC via the RESOURCE command, which indicates which memory type, with a specified number of bytes, at a specified address, may be used by the compiler. In the minimum configuration, the MBC has a single PCF8582 sEEPROM, which is connected as explained last month. The associated RESOURCE directive looks like this:

```
RESOURCE IIC-EEPROM 0100H BYTES
@05000H
```

This tells the compiler that an I^2 EEPROM is connected which is 100H bytes large, and mapped from address 5000H onwards. The general form of the RESOURCE command is

```
RESOURCE memory type length  BYTES
@address
```

Possible memory type indicators are:

IIC_EEPROM	means any I^{2}C EEPROM which is addressed like a PCF8582;
IIC_RAM	means any I^{2}C RAM which is addressed like a PCF8571;
8051-IRAM	means internal RAM of the 8051;
8051-XRAM	means external data memory of the 8051.

When the indicator '8051-IRAM' is used, you should observe the locations already used by the MatchBox interpreter in the internal RAM. This is the range from 00H to TOP, where TOP is indicated by the MatchBox at start-up. In version v0.3, for example, TOP equals 66H. Consequently, you may use the internal RAM range from 67H to 7FH. The '8051-XRAM' option enables you to address externally connected memory. As usual with the 8051, this memory has to be hooked up via an address latch. This possibility enables 'experts' to realize large data storage areas. The 'length' parameter simply indicates the number of bytes available in a particular memory device. The maximum value of this parameter is 8,192 bytes. The length may be indicated in decimal or hexadecimal notation. Hexadecimal notation is marked by a suffix H, for instance, 200H = 512 decimal. Finally, the start of the address range available to the MBC is indicated after the @ (hash) sign.

The start address of I^{2}C devices is derived as follows from the I^{2}C device address. For example, with the PCF8582 on the MatchBox board, the A2, A1 and A0 inputs are all held at '0'. Consequently, you first have to send a byte which represents address 101000xB, where x=1 for read operations, or x=0 for write operations. Removing the 'x' bit, we get the bit sequence 1010000B, which equals 50H. That sequence forms the most significant address specification with the RESOURCE command. The least significant byte is the start address of the range within the 256-byte page in an I^{2}C EEPROM. Another example. The PCF8570 has the following address wiring: A2=1, A1=1, A0=1. This corresponds to I^{2}C address 1011111xB. If you want to allocate the first 16 bytes to the MBC, you write

```
RESOURCE IIC_RAM 10H BYTES @5F00H
```

The use if the RESOURCE command in a number of different forms is the subject of comment in various example programs found on your courseware diskette. These are good places to learn more about this type of command. Finally, be sure to avoid address conflicts between I²C devices (for example, when connecting the real-time clock and several EEPROMs).

Logic combinations

Almost any type of programming requires values to be combined in several ways. As with variables, 'values' may mean numbers, bit patterns, flags, text characters, etcetera. The possibilities to combine such values may be designated 'arithmetic operations'. These are the subject of the following descriptions, which concentrate, basically, on what appears to the right of the '=' (equal to) sign. That is called, as explained above, a 'value', or, frequently, an arithmetic expression.

Assigning a value

Assigning serves to move a value somewhere, which is another way of saying that it is being stored. The target is called the location. The general notation for assigning as supported by the MatchBox is:

```
Location := Value
```

A few examples may help to illustrate the principle:

```
A:=2+3    ; Location is A ; Value
            equals value 2 + value 3
B[4]:=X.2+10/Y
P1:=1010B
```

Values may take a large number of different forms, all of which may be used to perform arithmetic operations with. These different forms are discussed below, along with the allowed locations.

An additional point regarding arithmetic: if a BYTE (for instance, a Port) is fetched, it is converted into a 16-bit value during the subsequent processing. This is done simply by adding leading zeroes. Values are, therefore, never computed 16-bit wide. If a value (that is, a 16-bit word) is assigned a location which has only eight bits, the eight most significant (left-most) bits of the value are ignored.

Numbers and variables

The simplest values are numbers, which the MatchBox understands in different forms: decimal, hexadecimal (suffix 'H') or binary (suffix 'B').

Hexadecimal numbers must start with a figure between 0 and 9. If necessary, a leading zero should be added. The value 0FFFFH therefore equals 65535 (decimal), while just FFFFH is not allowed as a hexadecimal value. The binary or hexadecimal notation greatly improves the readability of bit patterns and bit masks.

Numbers by themselves will not get you very far in programming. Therefore, variables are also allowed as values. The notation of a variable name then indicates the value of the variable.

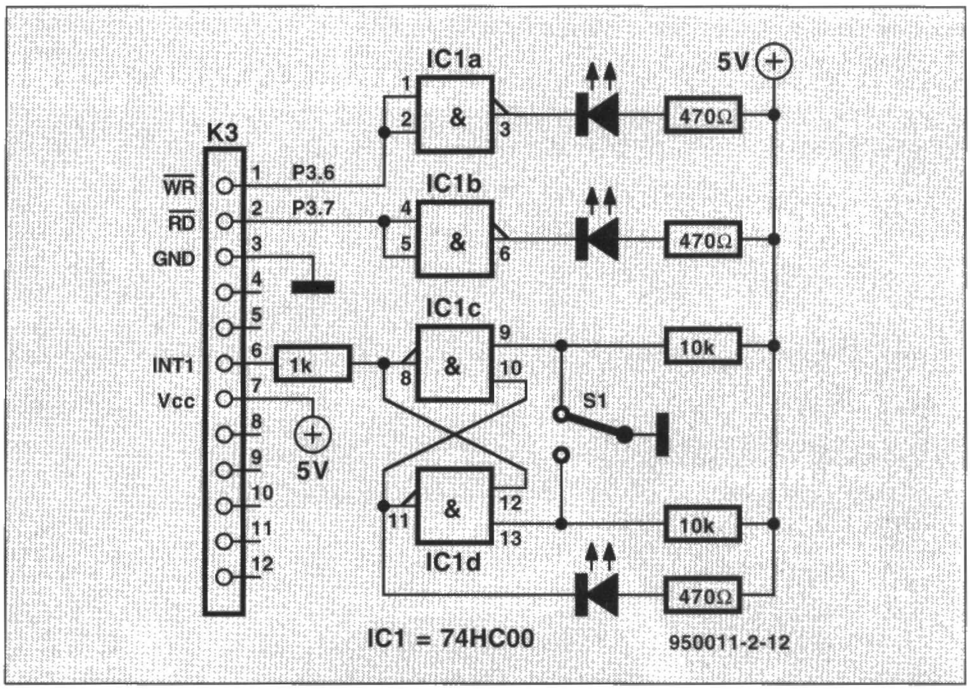


Fig. 2. Extension circuit which enables the MBC to drive two LEDs, and read one switch.

```
REM The EIT (Elektor
REM Item Tracer) will
REM tell you almost
REM instantly
REM where to find all
REM our earlier
REM publications
REM covering 8051-
REM family microcon-
REM trollers.
REM The same for I2C
REM integrated
REM circuits and PC
REM interfaces.
```

Ports

The ports of the 8051 microcontroller are used to connect simple extensions like switches and relay drivers. The ports consist of input and output lines, eight of which are bundled to form a byte. These ports are accessible, which means that you may change the level of their lines may be changed (Port output), or read (Port input). To gain access to the ports of the 8051, the usual notations may be employed. If you write

```
P1:=01110001B
```

then the bit pattern 01110001 is output on port P1. Looking at the individual bits, bits 0, 4, 5 and 6 are pulled high (1), while all other bits are held low (0). Thus, a port may also be used as a location. The state of a port may be requested simply by using the port designation as a value. For example, to fetch the state of port P1 and copy it into variable X, you program

```
X:=P1
```

Ports P1 and P3 allow individual bits to be controlled, without affecting the state of the others. For instance, to set bit 3 of port P1, you write

```
P1.3:=1
```

Likewise, individual bits (of any port) may be addressed and interrogated, for example:

```
IF P2.5=1 THEN ...
```

In this way, you have simple but effective control over, say, a lamp or a relay which is driven by a port line. Likewise, the state of an external logic signal may be captured easily via a port line. Even the notation 'P1.x' is allowed in this BASIC, and may be assigned a value, provided 'x' is an

allowed value. In this way, variable bit positions may be written.

An example

A program is shown which creates a flashing LED. The flash rate is programmable by pressing a key. The program requires the small auxiliary circuit shown in **Fig. 2**. By the way, this circuit is also used in the next instalment of this course, so you had better keep it. The duration of the flash period is contained in variable 'T'. The variable 'TCNT' counts down from 'T' to nought, and then changes the state (on/off) of the LED. When key 'S' is pressed, the value of 'T' is incremented starting from 1, until the key is released. The current value of 'T' is output to the PC via the RS232 link for verification. The LED starts to flash again when the key is released. The complete program listing is given in **Listing 3**.

Next time

Next month's third instalment of this series will concentrate on arithmetic combinations, formatted output, and I²C and LCD device connections. Also scheduled is an introduction into subroutine calls. (950011-2)

```
Listing 3


; PROG3.MBL
; subject:   programmable flashing light
;
;
RESOURCE IIC-EEPROM  0100H BYTES @05000H ; declare EEPROM
RESOURCE 8051-IRAM  10H BYTES @070H      ; use 8051 internal RAM
INTEGER T,TCNT                           ; declare variables
FORMAT(U 1 D )                           ; RS232 output format
P3.7:=0                                  ; Led at P3.7 off
T:=10                                    ; flash period default value
TCNT:=T                                  ; initialize time count
start:                                   ; main loop starts here
   IF P3.3=1 THEN                        ; set new time T if key
pressed
     T:=1                                ; starting with T=1
     WHILE P3.3=1 DO                     ; as long as key pressed :
       T:=T+1                            ; increment value
       PRINT(T,'    ')                   ; out value via RS232
       WHEND
     TCNT:=T                             ; initialize count again
     ENDIF ;
   TCNT:=TCNT-1                          ; decrement count
   IF TCNT<=0 THEN                       ; if time over
     P3.7:=P3.6                          ; turn on LED at P3.7
     P3.6:=NOT P3.6                      ; toggle LED at P3.6
     TCNT:=T                             ; initialize count again
   ENDIF
GOTO start                               ; start all over
END                                      ; end of source code
```

APPLICATION NOTE

The content of this note is based on information received from manufacturers in the electrical and electronics industries or their representatives and does not imply practical experience by *Elektor Electronics* or its consultants.

National Semiconductor's LM2575 as voltage inverter

By G. Kleine

It is often necessary to derive a negative voltage from an available positive supply line. This requirement is conveniently met by National Semiconductor's Type LM2575 regulator IC, which was first introduced in *Elektor Electronics* in March 1991. National Semiconductor calls the device a 'Simple Switcher'.

Basic circuits with the LM2575

A basic circuit of the LM2575 as a step-down regulator is shown in **Fig. 1**. It converts a fairly high input voltage into a much lower output voltage with an efficiency of 80–90%, which is appreciably higher than obtainable with a linear regulator. Consequently, the dissipation and heating are relatively small.

The device is available in presettable form (LM2575-ADJ) or as several fixed-voltage versions (LM2575T-xx) or LM2575HVT-xx), where 'xx' is the output voltage. The LM2575T operates from input voltages up to 40 V, the LM2575HVT up to 60 V. Each of these is available with standard output voltage of 3.3 V, 5.0 V, 12 V and 15 V. The 'T' refers to a 5-pin TO220 case, but versions in 4-pin TO3, SO14 and DIL16 cases are also available.

These regulators need only a loading coil, a Schottky diode and a couple of decoupling capacitors to form a complete circuit. The presettable versions also needs a reference potential divider, R_1, R_2.

The FB-pin of the fixed-voltage regulators must b connected to the output voltage. The rating of the electrolytic capacitors must, of course, correspond with the peak output voltage.

Step-up regulators Type LM2577 are intended to derive an output voltage that is higher than the input voltage, for example, 12 V from a 5 V input. In this case, the loading coil and the Schottky diode, D_1, are in series with the current flow—**Fig. 2**. As in Fig. 1, R_1, R_2 form a potential divider that divides the output voltage by 1.23. The output voltage is easily computed with the formula given. The LM2577 is also available in presettable and fixed-output form, but only 12 V and 15 V versions.

LM2575 as voltage inverter

If a negative supply voltage is required, the LM2575 may be used in an inverter circuit: in **Fig. 3a** this is arranged with an LM2575-ADJ. Loading coil L_1 is connected to ground, while the (negative) output is available from the GND pin of the regulator. As before, potential divider R_1-R_2 determines the level of the output voltage. In the computation, note that the drop across R_2 is always 1.23 V, which fixes the level of current through this resistor. The potential across R_1 is U_0–1.23 V. Since the current through the two resistors is the same, the value of R_1 can be calculated. The values of the resistors for various output voltages is given below.

U_0 (V)	R_1 (kΩ)	R_2 (kΩ)
3.3	1.2	0.68
5.0	3.3	1.0
9.0	7.5	1.2
12	10	1.1
15	7.5	0.68

If the output voltage is –5 V, the circuit in Fig. 3a may be simplified to that in **Fig. 3b**, which uses a Type LM2575-5.0. A potential divider preset for 5.0 V is available on board the regulator: connecting the FB terminal to

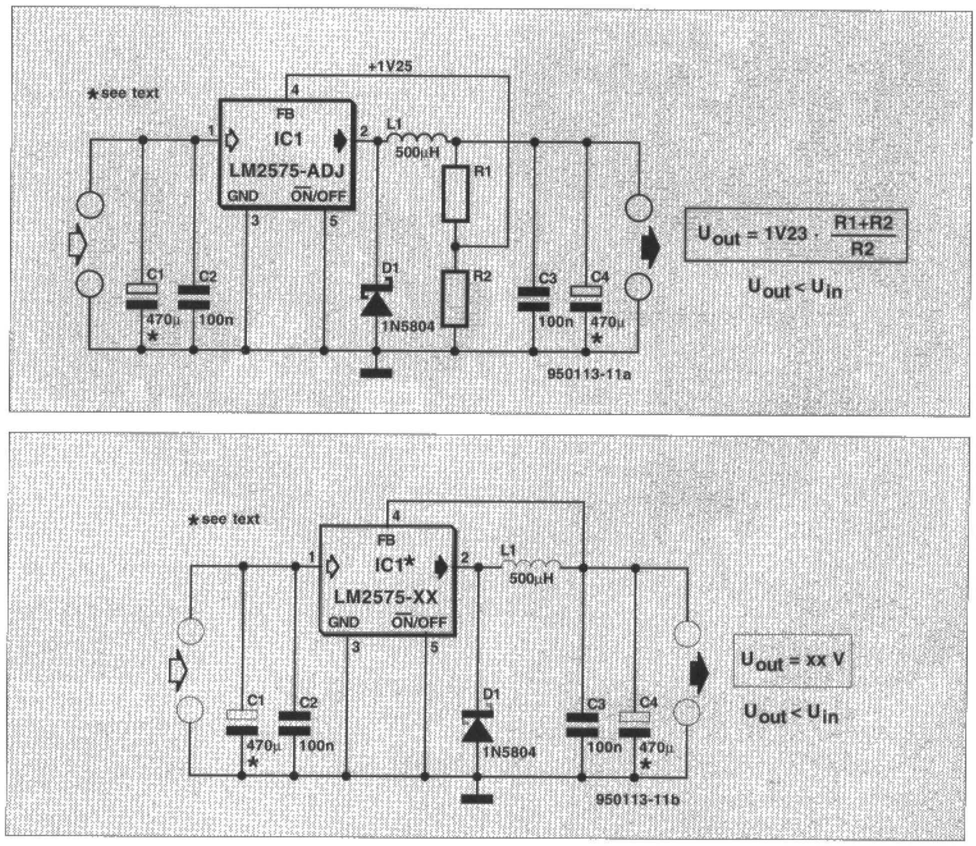


Fig. 1. Basic circuits of the LM2575: (top) ADJ(ust) version; (below) fixed-voltage version.

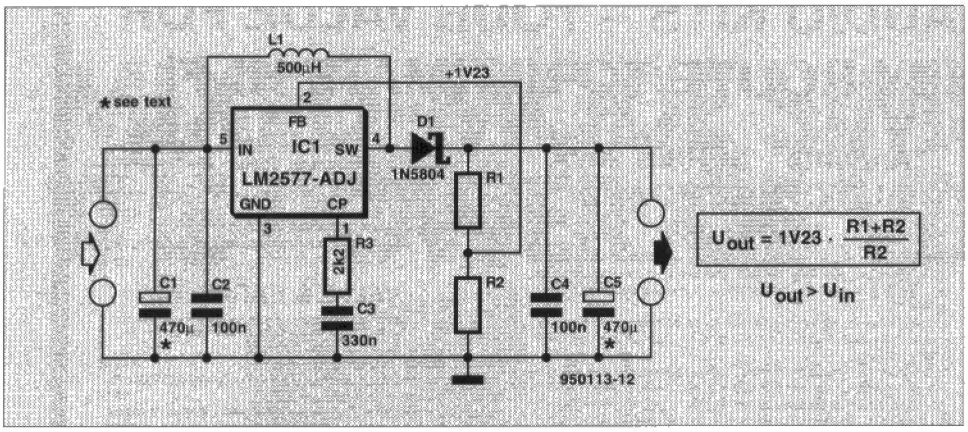


Fig. 2. Step-up regulator Type LM2575T.

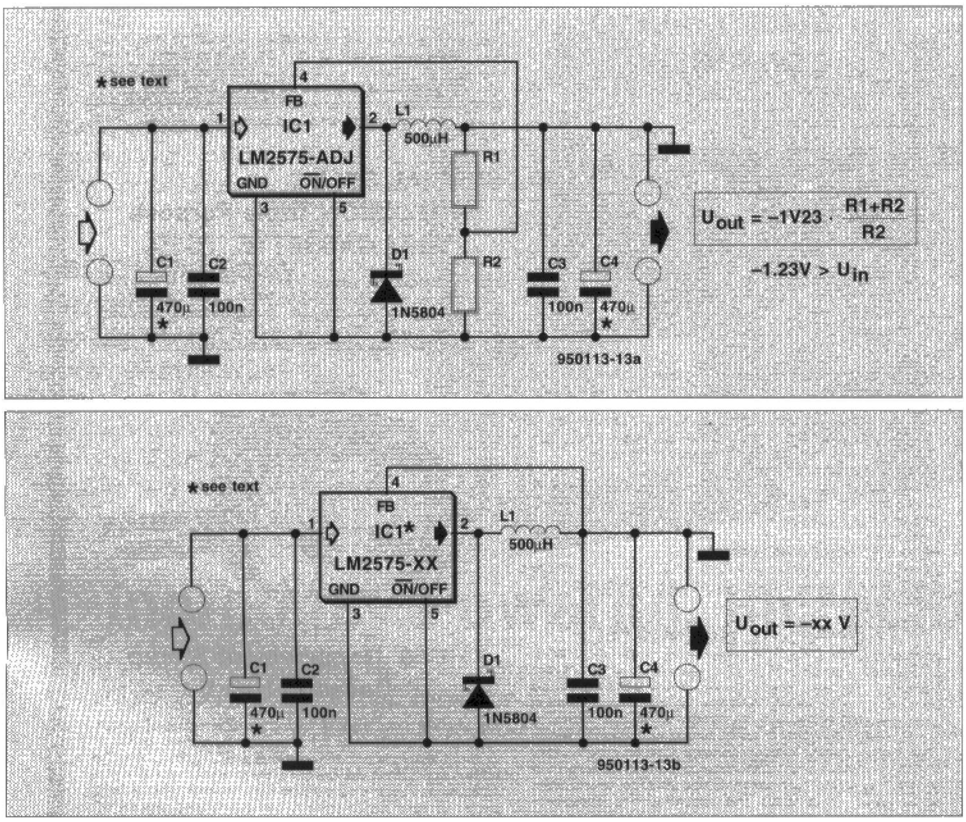


Fig. 3. Voltage inverter with (top) LM2575T-ADJ, and (below) with LM2575T-xx.

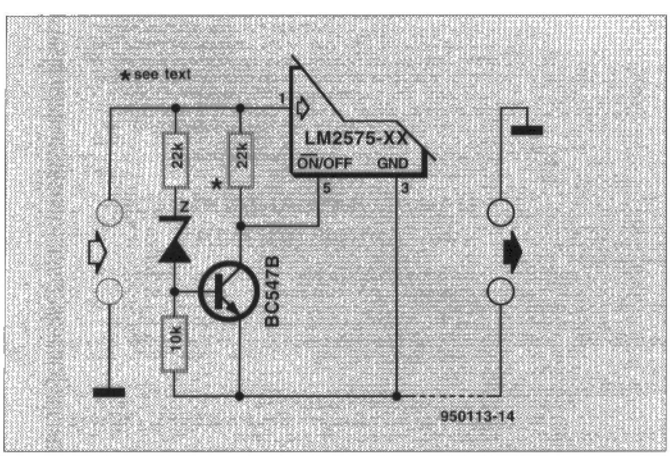


Fig. 4. Undervoltage protection for Fig. 3.

the output is all that needs to be done.

In the step-down circuit, the current through the LM2575T is about 1 A. In the inverter circuit, however, an appreciably higher current flows in the loading coil, so that the output current may be much lower than 1 A. For instance, with an output voltage of −12 V, the maximum output current is 350 mA. But, with an output voltage of −5 V, the peak output current is very nearly 1 A.

If a potential drop of more than 40 V across the device is expected, it is advisable to use a Type 2575HVT, which is suitable up to 60 V.

When the supply is switched on, a much higher starting current flows through the device than when it is used as a regulator. This may cause a problem if the supply cannot provide a current higher than 1.5 A. The input voltage then dos not rise fast enough and this prevents the regulator from working: it behaves as if there is a short-circuit. In such a case, the circuit in **Fig. 4** may prove useful: this causes the LM2575T to be enabled only when the input voltage to it is high enough. The rating of the zener diode is such that the transistor is not switched on until the input voltage is only a few volts below its nominal value.

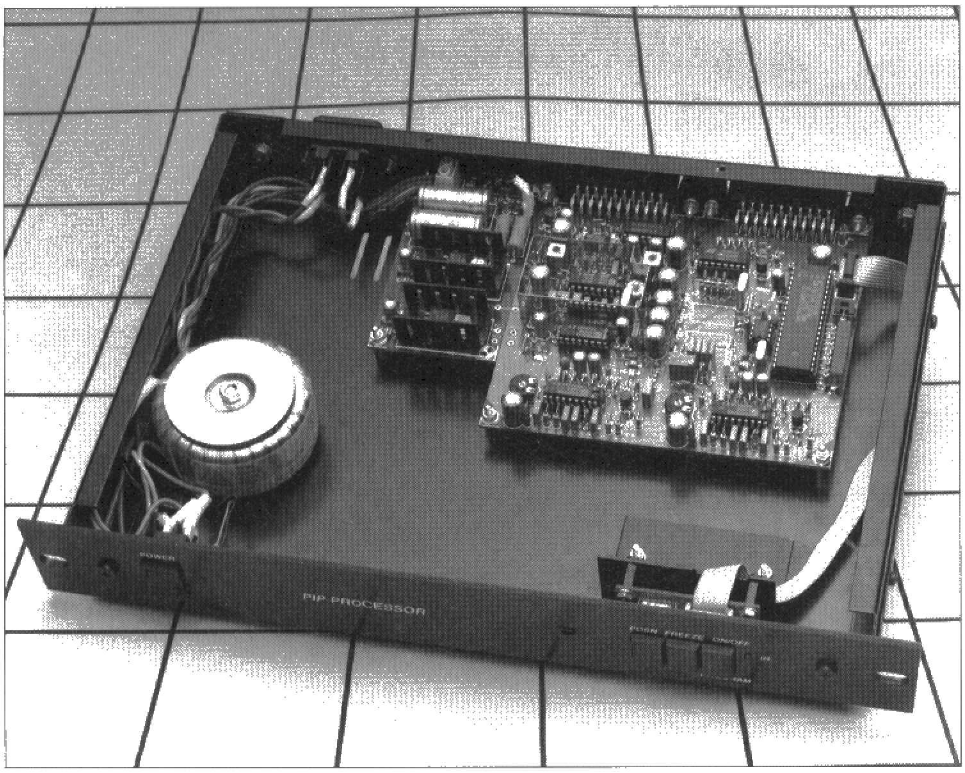
It is important to not that the TO220 case of the LM2575T is connected to GND pin 3. Since, in the inverter circuit, ground is at a negative potential, the case must not be connected to the circuit earth, but must be seated on an appropriate insulating washer.

National Semiconductor has available a PC program called *Switchers Made Simple*, which generates a circuit diagram, automatically calculates the values of the components, and generates a list of components.

[950113]

PICTURE-IN-PICTURE PROCESSOR
(PART 2, FINAL)

The PIP unit is a clever bit of electronics which allows a small picture to be inset in a corner of a normal TV picture. Having described the electronic operation of the unit in last month's instalment, we now tackle the construction and programming of the beast.



Design by W. Sevenheck

Last month we already mentioned that the PIP processor needs to be programmed with I^2C commands. No cause for alarm, because that entire function is handled by the internal microcontroller, IC_{11}. Even if you do not program anything, the unit will work fine for most applications because it then uses its default settings. Much of the programming information given here is, therefore, aimed at those of you who want to know a bit more about the actual operation of the PIP processor, or wish to change certain settings.

When the supply voltage is switched on, the PIP processor is reset, and bus lines SDA and SCL are enabled. All bits in the ten registers of the processor (except PL27, bit d3 in register 0) are then cleared to '0'. The SDA9188-3X then operates in slave mode, and works only when the 'inset' clock, LL3I, is present. The basic structure of an I^2C command may be found in Table 2 in last month's instalment. Register addresses are automatically incremented after a byte has been transferred, so that the next higher address is quickly available for reading or writing. It goes without saying that the plethora of functions and options offered by the registers inside the PIP chip core fully justifies the use of a microcontroller.

There are two ways of changing the contents of a PIP register: via an RC5 (Philips) compatible infra-red remote control, or via the three presskeys on the front panel of the unit. The microcontroller does all the decoding of the received RC5 commands. It also scans the presskeys for activity, and ensures that the correct I^2C instructions are sent to the PIP core.

Programming the PIP core is not exactly easy, and that is why the control program in the 8751 arranges for a number of default settings to be copied into the EEPROM at power-on. In practice, that means that you have a working PIP unit the minute you complete the construction.

The normal operation of the unit is quite simple using the three presskeys on the front panel:

Key 1 (ON/OFF):	PIP on/off;
Key 2 (FREEZE):	switch between moving and still PIP picture;
Key 3 (POSN):	the PIP picture jumps between four positions in the main picture. Press again to select desired position.

These functions will be the most frequently used in practice.

The PIP unit is switched to programming mode by keeping the ON/OFF key pressed for about 5 seconds. In programming mode, all registers of the PIP processor may be modified bitwise. This programming may appear difficult at first because it is done with just the three presskeys, meaning that every one of these has several functions. Fortunately, the job is not difficult to master, it only requires some practicing to get used to. In programming mode, the ten LEDs arranged next to the 87C51 indicate the current position, as well as the selected addresses and registers. It is recommended to first make a list of the desired settings, so that you know exactly what needs to be changed in the PIP core registers. The two-page overview at the end of this article shows all registers inside the SDA9188-3X, and the functions of the bits.

LED D_{10} lights when you enter programming mode. LEDs D_1 through D_8 then indicate the current register address in binary 'notation', i.e., LED D_1 represents the least significant bit. The ON/OFF and POSN keys are used to increase and decrease the register address respectively. A total of 16 registers may be programmed; ten inside the PIP core, and six in the 87C51. You leave the programming mode without

making any changes in the EEPROM by stepping up beyond address 15, or down beyond address 0. In either case, LED D_{10} will go out.

After selecting the desired register, you have to choose the low or high nibble of the byte with the aid of the FREEZE key (within 3 s). The low nibble is selected when D_{10} lights and D_9 is off. The high nibble is selected when D_{10} and D_9 flash. Next, you may enter the new register contents with the aid of the FREEZE key. The register contents are displayed in binary notation by LEDs D_1 through D_8. To return to normal mode, and save the new value(s) in EEPROM, all you have to do is wait 20 s before D_{10} goes out automatically. The programming operation is summarized in **Table 3**.

Key	Action	D10	D9	D8-D1
1	Press for 5 s until D10 lights	1	0	register address
3	Decrement register address, programming mode left without storing settings when address < 0	1 0	0 0	register address – 1 off
1	Increment register address, programming mode left without storing settings when address > 15	1 0	0 0	register address + 1 off
2	D9 on/off for high/low nibble - after 3 s D10 and D9 flash - after 3 s D10 flashes, D9 off	1 F F	x F 0	register address high nibble low nibble
2	Increment register contents	F	x	new nibble contents

1=LED on, 0=LED off, x=LED on or off, F=LED flashes

Table 3. Programming the PIP core register array with the aid of the presskeys.

The table overview for the SDA9188-3X starts with a summary of the register contents. Then follow the individual registers. Note that there are nibbles which do not consist of exactly four bits (in the 'I²C bus register' table, the division is indicated by a small shaded bar). Also note that the low nibble of register 4 is blocked, and can not be changed.

That concludes the programming of the PIP core. The 87C51 also has six registers ($0A_H$ through $0F_H$) which may be programmed by the user. These registers are shown in **Table 4**. Their programming is the same as described above for the PIP core registers. The 87C51's registers contain settings for the (software-implemented) RC5 decoder, the speed of the inset picture movement using S_3, and all default settings. The latter are particularly useful in case something goes wrong during manual programming of the registers.

When jumper J_1 is removed from the board, all default settings are copied into the EEPROM at the next complete reset (power-on). Next, you may fit J_1 again. Jumper J_2 is only essential if you play back a video tape. If it is not fitted, the tape picture is the main picture, and the TV picture goes to the inset. If J_2 is fitted, the inset picture is suppressed when the tape is played. It may be retrieved, however, by pressing S_1.

The normal functions of the three presskeys on the front panel of the PIP unit may be replaced by three RC5 (infra-red) commands which may be selected by the user. The software decoder has a 'learning' mode which enables the code to be stored by pressing a key on the RC5 remote control. The learning mode is left when LEDs D_1 through D_{10} indicate the return to normal mode. Incidentally, the software contained in the 87C51 also recognizes the extended RC5 code set.

When a continuous RC5 or EEPROM error exists in the system, the 87C51 reports that condition by displaying a running light on the LED bar. The only way out of this situation is by doing a hardware reset (remove J_1 and switch the power off and on again).

Construction and adjustment

Before you start soldering, cut off the keyboard section from the main board (**Fig. 8**). If necessary, the power supply section may also be cut off, and fitted separately in the enclosure. The supply section is then connected to the main board via three wires.

There are a few points to note as regards the fitting and soldering of the parts on the PCB. Firstly, the two PIP ICs come in SMA (surface mount assembly) cases, and have to be soldered at the **solder side** of the PCB (see also **Fig. 9**). It is recommended to solder the SMA ICs before the other components. Next, fit and solder capacitor C_{48} — also an SMA component — at the **component side** of the board. Do not use an ordinary (miniature) capacitor in this position — it may cause synchronization problems with the inset picture.

The second point regarding the construction is the tin-plate screen around the TDA4510 PAL decoder. This part of the circuit has a relatively high source impedance (because of the LC circuit at the input), and processes signals with a level of a few millivolts only. The screening also prevents the crystal located next to the decoder from interfering with the rest of the circuit. Such screening measures are not necessary for the other ICs in the circuit. The tin-plate sheet is first bent to give the right shape (approximately), and then secured to four solder pins on the board. This should be the last soldering action to the board.

The third point concerns inductors

Register address	Action	D10	D9	D8-D1
10 ($0A_H$)	Repositioning speed of PIP image (possible values: 1-5)	1	0	address
11 ($0B_H$)	Remote control: transmitted RC5 code valid for PIP ON/OFF	0	0	address
12 ($0C_H$)	Remote control: transmitted RC5 code valid for FREEZE	0	0	address
13 ($0D_H$)	Remote control: transmitted RC5 code valid for POSN	0	0	address
14 ($0E_H$)	Press FREEZE and POSN keys to load default values for registers 5-9, as well as PIP position and repositioning speed	0	0	x - x
15 ($0F_H$)	Press FREEZE, ON/OFF and POSN keys simultaneously to load all default settings	0	0	X - X

Table 4. Programming the dedicated 87C51 internal registers.

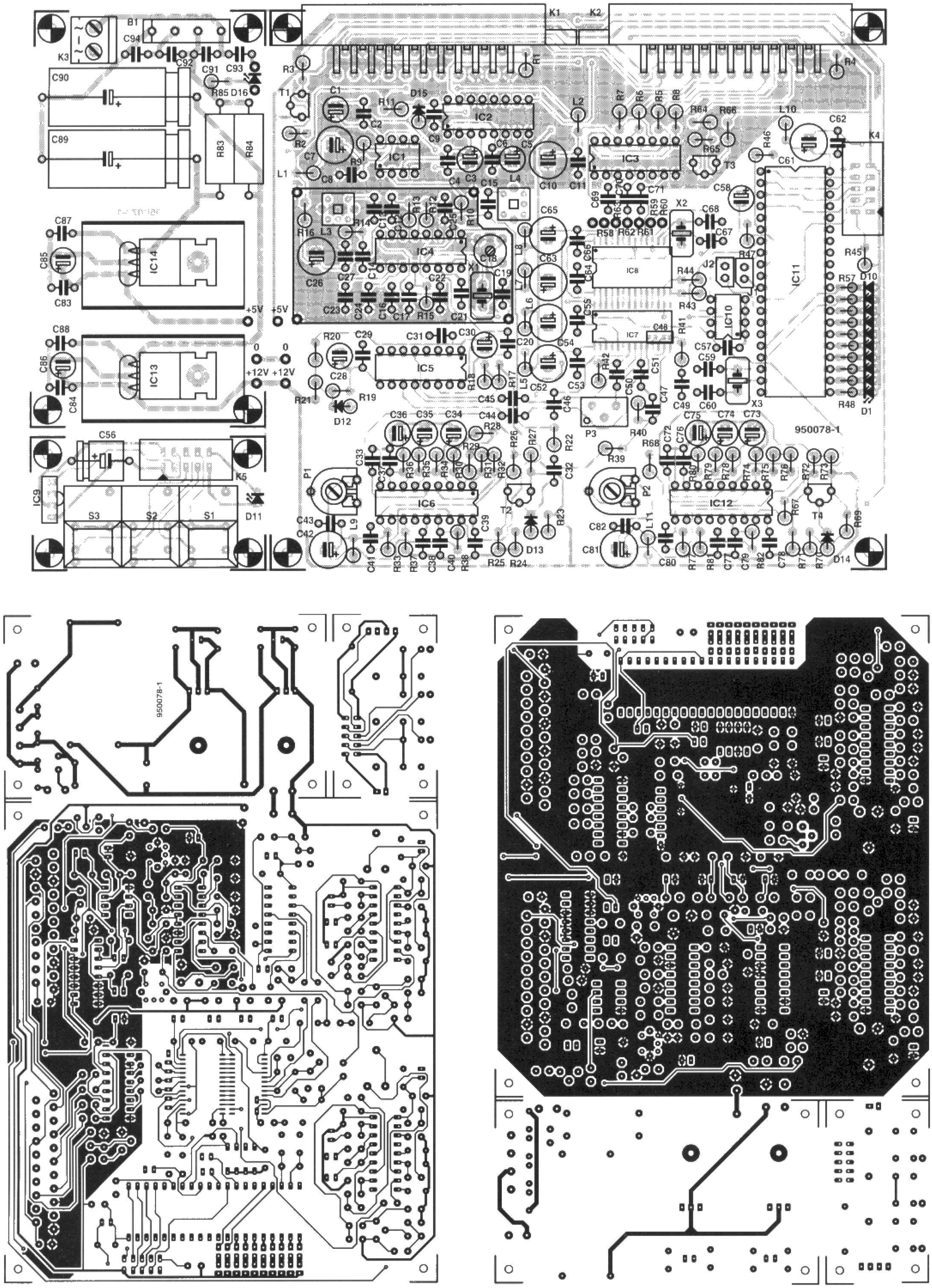


Fig. 8. This three-section, double-sided and through-plated printed circuit board greatly reduces the construction effort. Because of their size, the track layouts are printed at about 70% of their true size, and the component overlay, at about 90%. This board is available ready-made through the Readers Services (see page 70).

COMPONENTS LIST

Resistors:
R1;R4 = 75Ω
R2;R43;R44 = 100Ω
R3;R5;R6;R7 = 68Ω
R8 = 15Ω
R9;R17;R27;R28;R31;R60;R67;R73;R75;
R85 = 10kΩ
R10;R13 = 220Ω
R11;R12;R22;R26;R30;R33;R37;R72;R7
4;R77;R81 = 1kΩ
R14;R15 = 3kΩ3
R16 = 4Ω7
R18;R47;R59 = 8kΩ2
R19;R20 = 10Ω
R21 = 680Ω
R23;R69 = 12kΩ
R24;R34;R40;R70;R78 = 5kΩ6
R25;R71 = 820Ω
R29;R46;R48-R57;R68 = 2kΩ2
R32;R65;R76 = 100kΩ
R35;R79 = 22Ω
R36;R80 = 1kΩ2
R38;R82 = 39kΩ
R39;R58 = 6kΩ8
R41 = 56kΩ
R42 = 120Ω
R45 = 47Ω
R61;R62;R63 = 681Ω 1%
R64;R66 = 4kΩ7
R83 = 56Ω 5W
R84 = 2Ω2 5W
P1;P2 = 10kΩ preset H
P3 = 2kΩ multiturn preset, upright
(Bourns 3299Y)

Capacitors:
C1;C3;C5 = 4μF7 63V radial
C2;C4;C6;C8;C9;C11;C27;C43;C53;C55;
C57;C62;C64;C66;C69;C70;C71;C82;C8
3;C84;C87;C88 = 100nF ceramic
C7;C10;C26;C42;C52;C54;C61;C63;C65;
C81 = 220μF 25V radial
C12;C59;C60 = 33pF
C13;C15;C33;C72 = 150pF
C14;C29;C31;C44;C45;C46 = 10nF ceramic
C16;C23;C32 = 330nF 5mm
C17;C37;C76 = 47nF 5mm
C18 = 22p trimmer (small)
C19;C20 = 3nF3 5mm
C21 = 22nF 5mm
C22;C25 = 10nF 5mm
C24 = 470nF 5mm
C28;C30;C35;C74 = 22μF 40V radial
C34;C73 = 2μF2 63V radial
C36;C75 = 6μF8 35V tantalum
C38;C39;C41;C77;C78;C80 = 100nF
5mm
C40;C79 = 2nF2 5mm
C47 = 220pF
C48 = 1nF (SMD) *
C49 = 56nF 5mm
C50;C51 = 1μF MKT 5mm
C56 = 220μF 10V
C58;C85;C86 = 10μF 63V radial
C67;C68 = 15pF
C89;C90 = 1000μF 25V
C91-C94 = 47nF ceramic

Inductors:
L1;L2;L5-L11 = 47μH
L3 = 39μH = 55 turns ecw 0.1mm on former type 7A1S (Neosid).
L4 = 8μH6 = 27 turns ecw 0.2mm on former type 7A1S (Neosid).

Semiconductors:
B1 = B80C1500
D1-D10 = LED (flat)
D11;D16 = LED low current
D12 = 5V1 0W5
D13;D14 = 1N4148
D15 = 9V1 0W5
T1;T2;T4 = BC547C
T3 = BC547B
IC1 = TEA2014A (SGS-Thomson)
IC2 = 74HCT4053
IC3 = TEA5114A (SGS-Thomson)
IC4 = TDA4510 (Philips)
IC5 = TDA4661 (Philips)
IC6;IC12 = TDA2579B (Philips)
IC7 = SDA9187-2X (SMD) (Siemens)
IC8 = SDA9188-3X (SMD) (Siemens)
IC9 = SFH506-36 (Siemens)
IC10 = 24C02 (CB1) (SGS-Thomson)
IC11 = 87C51 (order code 956505-1, see page 70)
IC13 = 7812
IC14 = 7805

Miscellaneous:
K1;K2 = SCART socket, PCB mount.
K3 = 2-way PCB terminal block, raster 5mm.
K4 = two 5-way boxheaders (for S1, S2, S3 and D11).
K5 = two 5-way IDC style PCB mount connector.
S1;S2;S3 = Digitast presskey, w=12mm.
J1;J2 = 2-way pinheader w. jumper.
X1 = quartz crystal 8.867238 MHz.
X2 = quartz crystal 20.48 MHz.
X3 = quartz crystal 10 MHz.
Tr1 = mains transformer 15V/15VA.
Two heatsinks (for IC13 and IC14) 29K/W (e.g., Fischer ICK35SA) (Dau Components).
Enclosure: ESM type ET32/04, 21cm deep, w. black front panel.
mains appliance socket w. internal fuse holder and fuse, 100 mA slow ($I^2t \geq 0.03$).
Mains on/off switch.
Printed circuit board and ready-programmed 87C51, set order code 950078-C, see page 70.

* see text.

L_3 and L_4. These you have to wind yourself, using the data given in the parts list. It is not difficult, but do make sure the wires go to the right pins on the inductor base.

All ICs, with the obvious exception of the SMA PIP ICs, may be fitted in IC sockets. When mounting the crystals, make sure that their metal housing does not touch the PCB tracks, the screening or other components. All resistors (with the exception of R_{83} and R_{84}) and diodes are fitted upright. LEDs D_1 through D_{10} are fitted on to the printed circuit board, while D_{11} is fitted on the smallest sub-board, together with the presskeys and the IR receiver IC. This sub-board is fitted behind the front panel. On the power supply board, care should be taken that the two heatsinks (for IC_{13} and IC_{14}) do not touch the tracks underneath. That is simple to achieve by inserting a 5-mm thick washer between the board and the heatsink. This will give sufficient protection against short-circuits with copper tracks, and at the same time improves the heatsink's ability to dissipate heat. Although the remainder of the construction is straightforward, it still requires great care and precision. Do not use too much solder tin, and check your work after you have finished soldering.

The circuit should be adjusted before it is built into the metal enclosure. There are six adjustment points: three preset potentiometers, one trimmer capacitor and two inductors. Although you do not need specialized instruments to set up the PIP processor, a digital multimeter will prove useful. The inductors must be adjusted with a plastic trimming tool, because a metal screw driver would give too much stray capacitance. First, set P_1, P_2, P_3 and trimmer C_{18} to mid-travel. Connect SCART socket K_2 to the TV set via a **fully wired** SCART cable (many of the cheaper brands of SCART cable have only wires for the audio and video signals). Furthermore, you have to be sure that the RGB and blanking pins on the SCART socket of your TV are actually connected. If not, the circuit will not work properly. Select a channel with a clear picture on the TV. Next, connect the other video source to K_1. This source, for instance, the VCR's internal tuner, should supply a good quality CVBS signal. After switching on the supply voltage, press S_1 once. The inset picture should appear almost instantly. Presets P_1 and P_2 serve to adjust the basic frequency

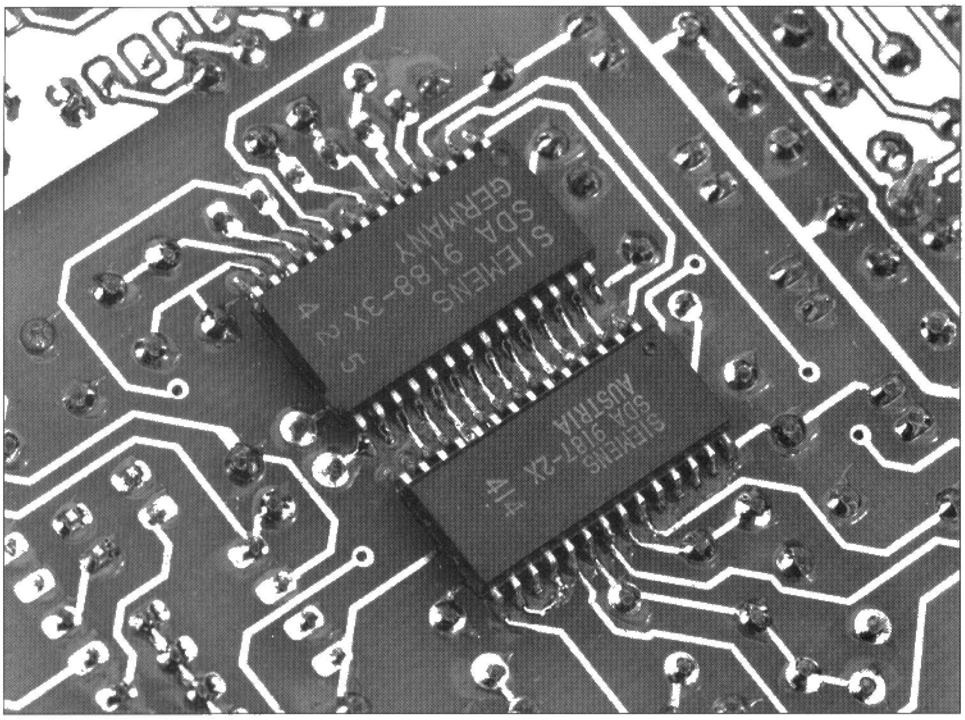


Fig. 9. This photograph shows the two PIP core ICs. These are surface-mounted devices (SMDs) which are fitted at the solder side of the board. It goes without saying that a solder iron with a fine tip is needed here. And good eyesight!

of the line oscillator. This frequency should be 15,625 Hz. First, adjust P_2 until the inset picture is horizontally stable. Turn the wiper back and forth to determine the range in which the inset is stable, and then set the wiper to the centre of that range. The same is done with P_2 for the vertical sync.

Preset P_3 determines the input sensitivity of the Y/U/V inputs of IC_7. This preset is adjusted for equal contrast between the main picture and the inset (tip: set the VCR and the TV to the same channel). The sensitivity will normally lie between about 0.5 V_{pp} and 0.95 V_{pp}, which may be measured across capacitor C_{50} (remember there is a direct voltage at this point).

Next, turn to the adjustment of the PAL chroma oscillator running at 8.867 MHz. Simply adjust trimmer C_{18} until the inset picture appears in colour.

Finally, concentrate on the two inductors. For the inset, select a TV channel which supplies a test chart, then adjust L_4 for minimum moiré (cross-colour patterning) in the picture. The other inductor, L_3, is adjusted for the best possible colour reproduction in the inset picture. The following is for guidance only: in our prototype, the top of the core of L_3 was about flush with the top of the metal case. The top of the core in L_4 was about 2 mm below the top of the metal case.

After the (successful) adjustment, the board may be fitted into the ESM case. The main board and the supply board are secured on the bottom plate of the case, while the keyboard PCB is secured behind the front panel with the aid of a clip or similar. A large rectangular clearance is made in the front panel for the keys, and two smaller, round, holes for the LED and the IR receiver IC. At the far left, drill the holes for the mains switch and the on/off LED.

The wiring between the boards is minimal: three wires between the supply board and the main board, and a length of flatcable between the main board and the keyboard. One end of the flatcable has an IDC socket. The other end is secured to PCB connector K_5. Clearances are made in the rear panel for the two SCART sockets and the mains appliance socket. Observe electrical safety when fitting the wiring between the mains socket, the mains on/off switch and the mains transformer. The SCART sockets should be secured tightly to the rear panel to avoid the PCB taking all the mechanical strain when a SCART plug is inserted or removed.

Right, everything constructed neatly? Then you may fit the top cover plate. Fit all the connections, switch on, and you are ready to enjoy the luxury of a PIP function on your TV.

(950078-2)

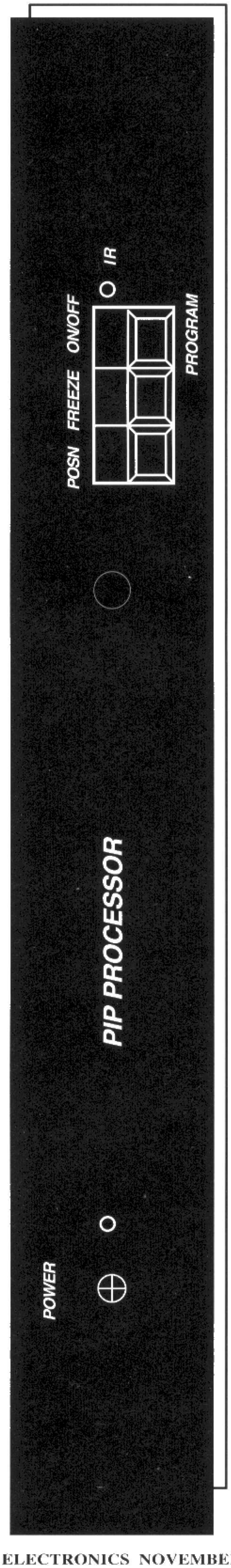


Fig. 10. Suggested layout of the front panel, printed at about 83% of actual size (front panel foil not available ready-made).

Organization of I²C bus registers in SDA9188-3X

Device address SDA9188-3X: 00101110 = $2E_H$

Write operation:

S	0010	1110	A	0000	XXXX	A	XXXX	XXXX	A	P
⇑ Start		Write ⇒	⇑ Ack							⇑ Stop
	Chip address byte			Register address			Data word 1			

Inset Picture size

Picture size	TV standard (inset) (no. of frame lines)	Number of pixels P			No. of lines L
		Y	U	V	
1/9	625	212	53	53	88
1/9	525	212	53	53	76
1/16	625	160	40	40	66
1/16	525	160	40	40	57

I²C bus register

Function	sub-address	high nibble				low nibble			
		D7	D6	D5	D4	D3	D2	D1	D0
CONTROL0	00_H	0	0	STILL	SIZE	PL27	NINT	OUT	PON
CONTROL1	01_H	0	0	0	FRY	COL2	COL1	COL0	FRON
CONTROL2	02_H	0	SD2	SD1	SD0	RDV3	RDV2	RDV1	RDV0
CONTROL3	03_H	POS1	POS0	RDH5	RDH4	RDH3	RDH2	RDH1	RDH0
CONTROL4	04_H	CON0	CON1	CON2	CON3	0	SOP	PLLOFF	HSP5
CONTROL5	05_H	DECVER	DECHOR	FRWV	FRWH	PMOD1	PMOD0	IMOD1	IMOD0
CONTROL6	06_H	FRAME	STATI	VSIIS	VSIDEL4	VSIDEL3	VSIDEL2	VSIDEL1	VSIDEL0
CONTROL7	07_H	AMSEC	STATP	VSPIS	VSPDEL4	VSPDEL3	VSPDEL2	VSPDEL1	VSPDEL0
CONTROL8	08_H	0	0	0	FRYEN	FRY5	FRY4	FRY3	FRY2
CONTROL9	09_H	0	PLLTC	SOS	VCOSEL3	VCOSEL2	VCOSEL1	VCOSEL0	0

Register 0 (Address 00_H)

Bit	Function	Name	Remarks
d0	0=PIP off 1=PIP on	PON	If d0=0 no SELECT generated d0=1 should be set after the initialization
d1	0=Y,-U,-V 1=RGB	OUT	Output format
d2	0=normal picture 1=double scan	NINT	Reproduction mode
d3	0=13,5 MHz PLL 1=27 MHz PLL	PL27	Switching of clock prescaler of the PLL for 50/60 Hz or 100/120 Hz operation mode
d4	0=1/9 1=1/16	SIZE	Picture size; if d4=0 the picture size depends on DECHOR, DECVER in Register 5
d5	0=normal picture 1=still picture	STILL	Still/moving picture
d6,d7	not assigned		

Register 1 (Address 01_H)

Bit	Function	Name	Remarks
d0	0=without frame 1=with frame	FRON	
d1-d3	frame colour d3 d2 d1 0 0 0 blue 0 0 1 purple 0 1 0 green 0 1 1 white 1 0 0 red 1 0 1 yellow 1 1 0 orange 1 1 1 cyan	COL0-COL2	
d4-d7	Intensity of the border frame 1=dark frame bright frame 0=bright frame dark frame	FRY	Only valid if FRYEN=0 for white,yellow,orange,cyan for blue,purple,green,red for white,yellow,orange,cyan for blue,purple,green,red
d5-d7	No function		

Register 2 (Address 02_H)

Bit	Function	Name	Remarks
d0-d3	Vertical read delay in HSP period d3 d2 d1 d0 0 0 0 0 = 0 0 0 0 1 = 2 0 0 1 0 = 4 ... 1 1 0 1 = 26 1 1 1 0 = 28 1 1 1 1 = 30	RDV0-RDV3	Increment in two HSP periods If POS1=1 is selected, i.e. 525-lines parent picture and 625-lines inset picture are displayed, then RDV bits are not evaluated
d4-d6	SELECT delay in LL3P period d6 d5 d4 0 0 0 = 0 0 0 1 = 1 0 1 0 = 2 0 1 1 = 3 1 0 0 = 4 1 0 1 = 5 1 1 0 = 6 1 1 1 = 7	SD0-SD2	
d7	no function		

Register 3 (Address 03_H)

Bit	Function	Name	Remarks
d0-d5	Horizontal read delay in LL3P period d5 d4 d3 d2 d1 d0 0 0 0 0 0 0 = 0 0 0 0 0 0 1 = 4 0 0 0 0 1 0 = 8 ... 1 1 1 1 0 1 = 244 1 1 1 1 1 0 = 248 1 1 1 1 1 1 = 252	RDH0-RDH5	Increment in four LL3P periods
d6,d7	Inset picture location d7 d6 0 1 top left 0 1 top right 1 0 bottom left 1 1 bottom right	POS0-POS1	

Register 4 (Address 04_H)

Bit	Function	Name	Remarks
d0	1=TTL level at HSP	HSP5	Set to 1
d1	0=internal PLL 1=external PLL	PLLOFF	Switching between internal and external clock generation
d2	0=Select int. pull-up 1=Select ext. pull-up	SOP	Open drain for Select output
d3	No function		Must be set to 0
d4-d7	Contrast D/A-converter d7 d6 d5 d4 0 0 0 0 1 0 0 0 0 1 0 0 ... 1 1 1 1	CON0-CON3	With an external resistor of 10 kΩ between V_{SS} and V_{REF} the output level for (d7-d4)=0001 is nearly the same as for 3.9 kΩ and (d7-D4)=0000 Min. contrast Max. contrast

Register 5 (Address 05_H)

Bit	Function	Name	Remarks
d1,d0	00=automatic TV standard recognition 01=50 Hz 10=60 Hz 11=freeze current mode	IMOD0-IMOD1	for multistandard applicat. Fixed setting Fixed setting Undisturbed switching during change of received station
d3,d2	same as d1,d0	PMOD0-PMOD1	as above for parent channel
d4	0=Frame width horizontal: 6 pixel 1=Frame width horizontal: 4 pixel	FRWH	Individual setting of frame width and height is possible e.g. for 16:9 operation
d5	0=Frame width vertical:3 lines 1=Frame width vertical: 2 lines	FRWV	Individual setting of frame width and height is possible e.g. for 16:9 operation
d6	0=Horizontal decimation 3:1 1=Horizontal decimation 4:1	DECHOR	Individual setting of picture width and height is possible e.g. for 16:9 operation, but only if Size=0 in Register 0
d7	0=Vertical decimation 3:1 1=Vertical decimation 4:1	DECVER	Individual setting of picture width and height is possible e.g. for 16:9 operation, but only if Size=0 in Register 0

Register 6 (Address 06_H)

Bit	Function	Name	Remarks
d4-d0	VSI delay setting	VSIDEL	Setting is possible in steps of 2.37 µs.
d5	0=Vertical noise reduction inactive 1=Vertical noise reduction active	VSIS	Noise reduction of VSI pulse (should be set to 1 under normal conditions).
d6	0=Check for correct TV standard inactive 1=Check for correct TV-standard active	STATI	If the check is active a full frame display is only possible if the number of lines is exactly according to the TV standard: 312.5 (50 Hz), 262.5 (60 Hz).
d7	0=Field display 1=Frame display	FRAME	Only active if line number and interlace mode are equal for both inset and parent signal. If display mode is 100/120 Hz or progressive scan, d7 has to be set to 0.

Register 7 (Address 07_H)

Bit	Function	Name	Remarks
d4-d0	VSP pulse delay	VSPDEL	Setting is possible in steps of 2.37 µs (50 Hz) or 1.185 µs (100 Hz)
d5	0=Vertical noise reduction OFF 1=Vertical noise reduction ON	VSPIS	Noise reduction for vertical pulse of parent channel (should be set to 1 under normal conditions)
d6	0=Check for correct TV standard inactive 1=Check for correct TV standard active	STATP	If check for correct TV standard is active, a full frame display is only possible if the number of lines is exactly according to to TV standard: 312.5 (50 Hz) or 262.5 (60 Hz)
d7	0=PAL/NTSC 1=SECAM	AMSEC	Doubling of the gain if an appropriate SECAM decoder without delay line is used

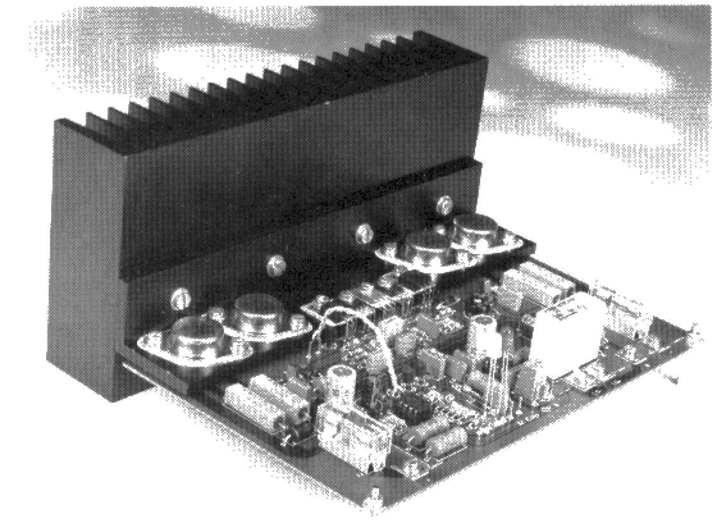
Register 8 (Address 08_H)

Bit	Function	Name	Remarks
d3-d0	0000=min. brightness of the border frame 1111=max. brightness of the border frame	FRY5:2	Setting only valid if bit d4 d4 is set to 1
d4	0=brightness of border frame selected by FRY 1=brightness of border frame selected by FRY5:2	FRYEN	
d7-d5	not used		To be set to 0

Register 9 (Address 09_H)

Bit	Function	Name	Remarks
d0	-		Set to 0
d1-d4	VCO nominal frequency	VCOSEL 0-3	Set to 0 under nominal conditions
d5	Select open source	SOS	If d5=1 pull-down transistor of select output is switched off. Resistor to ground required!
d6	PLL time constant	PLLTC	0=fast time constant 1=slow time constant
d7	-		Set to 0

PA300 POWER AMPLIFIER



Design by A. Riedl

Taken by themselves, the properties of the PA300 amplifier are not revolutionary. But taken in combination, they show something special: a robust 300 watt hi-fi power amplifier that is not too difficult to build.

There are several starting points to the design of a power amplifier: pure hi-fi without any compromise; simplicity and reliability; high output power. The design of the present amplifier is a mixture of these. The result is a unit that does not use esoteric components, is not too complex, and is fairly easily reproduced. In fact, it could well be named a 'Hi-fi public address amplifier'.

There will be a few eyebrows raised at the power output of 300 watts (into 4Ω); it is true, of course, that in the average living room 30–40 W per channel is more than sufficient. However, peaks in the reproduced music may have a power of 10–20 times the average level. This means that some reserve power is desirable. Also, there are loudspeakers around with such a low efficiency that a lot more than 30–40W is needed. And, last but not least, there are many people who want an amplifier for rooms much larger than the average living room, such as an amateur music hall.

Straightforward design

Since every amplifier contains a certain number of standard components, the circuit of **Fig.1** will look pretty familiar to most audio enthusiasts. Two aspects may hit the eye: the higher than usual supply voltage and the presence of a couple of ICs. The first is to be expected in view of the power output. One of the ICs is not in the signal path and this immediately points to it being part of a protection circuit. What is unconventional is an IC in the input stage. Normally, this stage consists of a differential amplifier followed by a voltage amplifier of sorts, often also a differential amplifier, to drive the predriver stages. In the PA300, the entire input stage is contained in one IC, a Type NE5534 (IC_1).

The internal circuit of IC_1 is shown in the box on further on in this article. It may also be of interest to note that the NE5534 is found in nine out of every ten CD players (as amplifier in the analogue section). This is reflected in its price which is low. Its only drawback is that its supply voltage is far below that of the remainder of the amplifier. This means an additional symmetrical supply of ±15 V. Moreover, it restricts the drive capability of the input stage. The supply requirement is easily met with the aid of a couple of zener diodes and resistors. The drive restriction means that the amplifier must provide a measure of voltage amplification after the input stage.

Circuit description

The input contains a high-pass filter, C_5-R_3 and a low-pass filter, R_2-C_6. The combination of these filters limits the bandwidth of the input stage to a realistic value: it is not necessary for signals well outside the audio range to be amplified – in fact, this may well give rise to difficulties.

Opamp IC_1 is arranged as a differential amplifier; its non-inverting (+) input functions as the meeting point for the overall feedback. The feedback voltage, taken from junction D_7-D_8, is applied to junction R_4-R_5 via R_9. Any necessary compensation is provided by C_9, C_{12} and C_{14}. The voltage amplification is determined by the ratio R_9:R_5, which in the present circuit is ×40.

The output of IC_1 is applied to drive stages T_1 and T_3 via R_6. These transistors operate in Class A: the current drawn by them is set to 10 mA by voltage divider R_{10}-R_{13} and their respective emitter resistors. Their voltage and current amplification is appreciable, which is as required for the link between the input and output stages.

The output amplifier proper con-

Technical data (measured with power supply shown in Fig. 2)

Input sensitivity	1 V_{rms}
Input impedance	17.8 kΩ
Power output (0.1% THD)	164 W into 8 Ω
	275 W into 4 Ω
Music power(500 Hz burst 5 cycles on, 5 cycles off)	176 W into 8 Ω
	306 W into 4 Ω
Power bandwidth (90 W into 8 Ω)	7 Hz–67 kHz
Slew rate	20 V/μs
Signal-to-noise ratio (referred to 1 W into 8 Ω)	>96 dB (A-weighted)
Harmonic distortion (THD+N) (bandwidth 80 kHz)	at 1 W into 8 Ω: <0.004% (1 kHz)
	at 150 W into 8 Ω: <0.001% (1 kHz)
	<0.05% (20 Hz–20 kHz)
Intermodulation distortion (50 Hz:1 kHz: 4:1)	at 1 W into 8 Ω: <0.003%
	at 100 W into 8 Ω: <0.0035%
Dynamic IM (rectangular wave + 15 kHz sine wave)	1 W into 8 Ω: <0.004%
	150 W into 8 Ω: <0.06%
Damping factor (at 8 Ω)	<345 at 1 kHz
	<275 at 20 kHz

sists of drive stages T_6 and T_7 and power transistors T_8, T_9, T_{14}, T_{15}, which have been arranged as symmetrical power darlingtons. Because of the high power, the output transistors are connected in parallel. The types used can handle a collector current of 20 A and have a maximum dissipation of 250 W.

The output stages operate in Class AB to ensure a smooth transition between the n-p-n and p-n-p transistors, which prevents cross-over distortion. This requires a small current through the power transistors, even in the absence of an input signal. This current is provided by 'zener' transistor T_2, which puts a small voltage on the bases of T_6 and T_7 so that these transistors just conduct in quiescent operation. The level of the quiescent current is set accurately with P_1.

To ensure maximum thermal stability, transistors T_1–T_3 and T_6–T_7 are mounted on and the same heat sink. This keeps the quiescent current within certain limits. With high drive signals, this current can reach a high level, but when the input signal level drops, the current will diminish only slowly until it has reached its nominal value.

Diodes D_7, D_8 protect the output

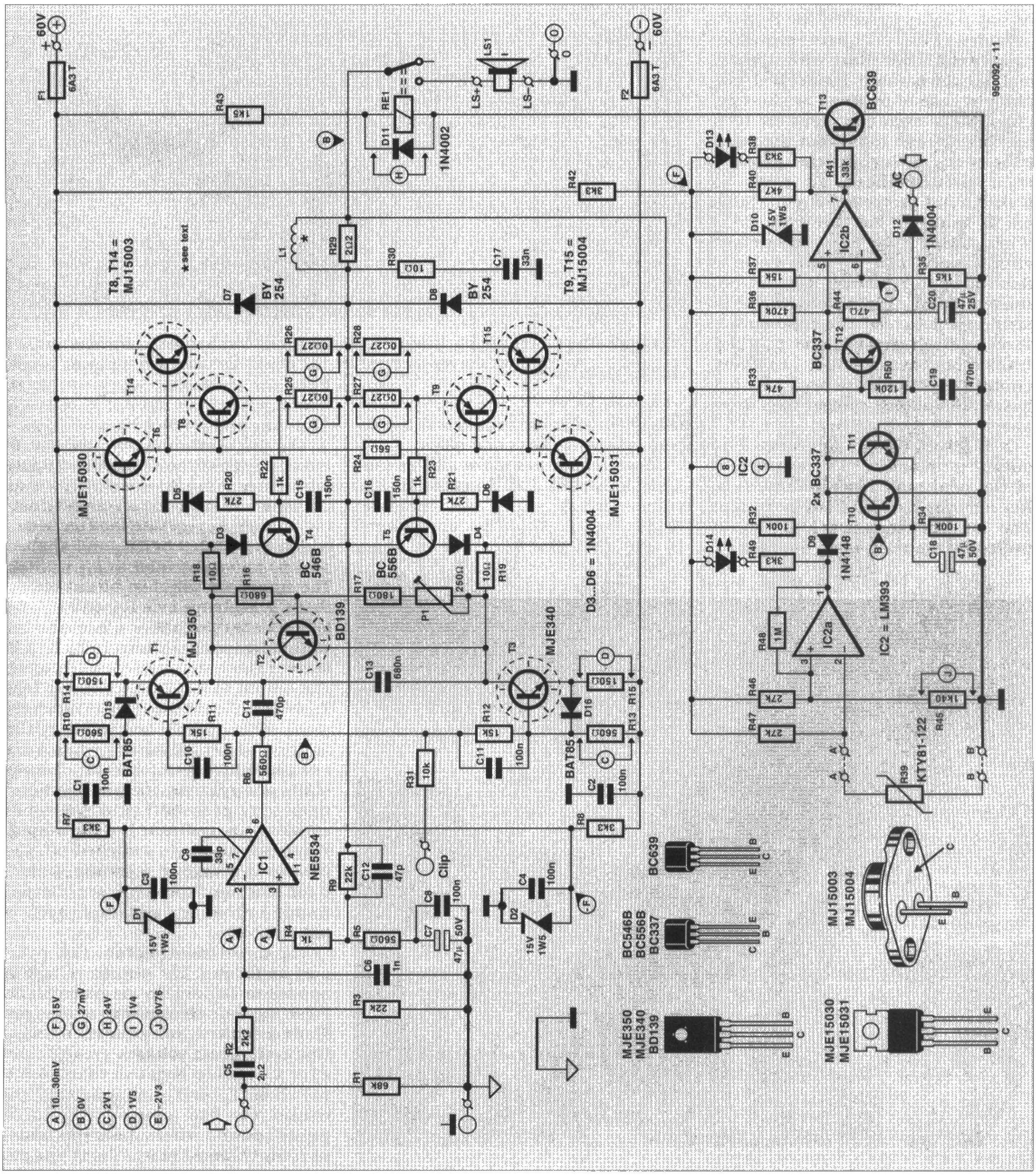


Fig. 1. With the exception of an IC at the input, the circuit of the PA300 amplifier is conventional.

stages against possible counter voltages generated by the complex load. Resistor R_{30} and capacitor C_{17} form a Boucherot network to enhance the stability at high frequencies. Inductor L_1 prevents any problems with capacitive loads (electrostatic loudspeakers). Resistor R_{29} ensures that the transfer of rectangular signals are not adversely affected by the inductor.

Protection circuits

As any reliable amplifier, the PA300 is provided with adequate protection measures. These start with fuses F_1 and F_2, which guard against high currents in case of overload or short-circuits. Since even fast fuses are often not fast enough to prevent the power transistors giving up the ghost in such circumstances, an electronic short-circuit protection circuit, based on T_4 and T_5, has been provided. When, owing to an overload or short-circuit, very high currents begin to flow through resistors R_{25} and R_{27}, the potential drop across these resistors will exceed the base-emitter threshold voltage of T_4 and T_5. These transistors then conduct and short-circuit or reduce drive signal at their bases. The output current then drops to zero.

If a direct voltage appears at the output terminals, or the temperature of the heat sink rises unduly, relay Re_1 removes the load from the output. The loudspeakers are also disconnected by the relay when the mains is switched on (power-on delay) to prevent annoying clicks and plops.

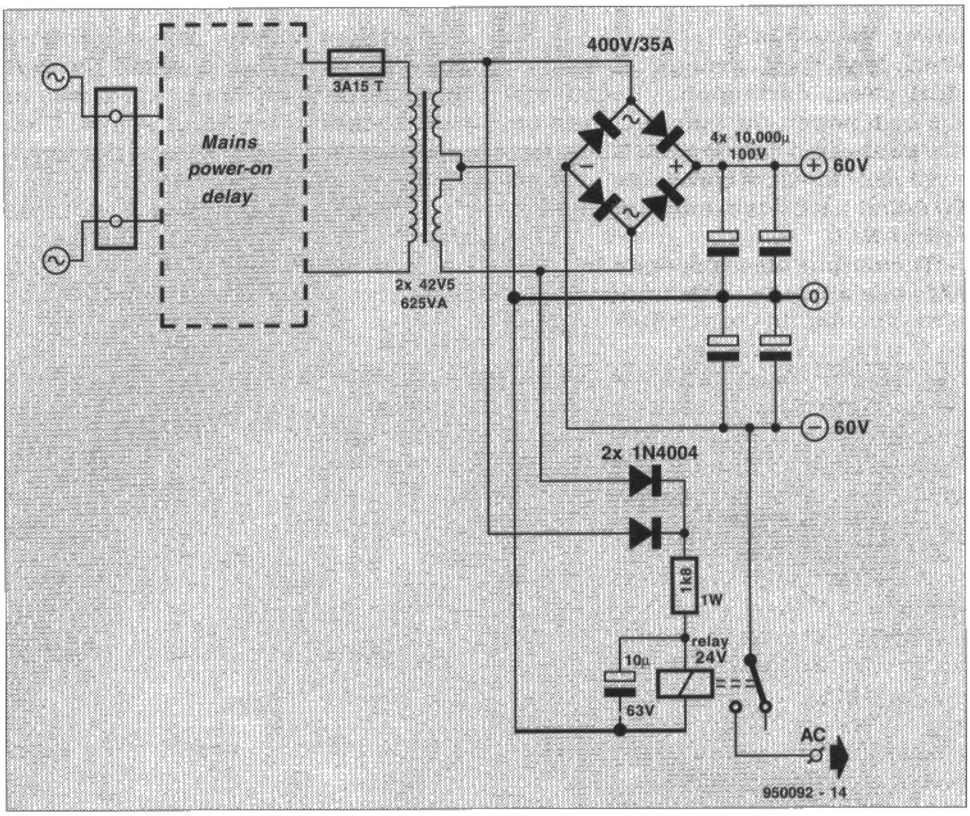


Fig. 2. The power supply is straightforward, but can handle a large current. Voltage 'AC' serves as drive for the power-on delay circuit.

The circuits that make all this possible consist of dual comparator IC_2, transistors T_{10}–T_{13}, and indicator diodes D_{13} and D_{14}. They are powered by the 15 V line provided by zener diode D_{10} and resistor R_{42}.

The 'AC' terminal on the PCB is linked to one of the secondary outputs on the mains transformer. As soon as the mains is switched on, an alternating voltage appears at that terminal, which is rectified by D_{12} and applied as a negative potential to T_{12} via R_{50}. The transistor will then be cut off, so that C_{20} is charged via R_{36} and R_{44}. As long as charging takes place, the inverting (+) input of comparator IC_{2b} is low w.r.t. the non-inverting (–) input. The output of IC_{2b} is also low, so that T_{13} is cut off and the relay is not energized. This state is indicated by the lighting of D_{13}. When C_{20} has been charged fully, the comparator changes state, the relay is energized (whereupon D_{13} goes out) and the loudspeakers are connected to the output. When the mains is switched off, the relay is deenergized instantly, whereupon the loudspeakers are disconnected so that any switch-off noise is not audible.

The direct-voltage protection operates as follows. The output voltage is applied to T_{10} and T_{11} via potential divider R_{32}-R_{34}. Alternating voltages are short-circuited to ground by C_{18}. However, direct voltages greater than +1.7 V or more negative than –4.8 V switch on T_{10} or T_{11} immediately. This causes the +ve input of IC_{2a} to be pulled down, whereupon this comparator changes state, T_{13} is cut off, and the relay is deenergized. This state is again indicated by the lighting

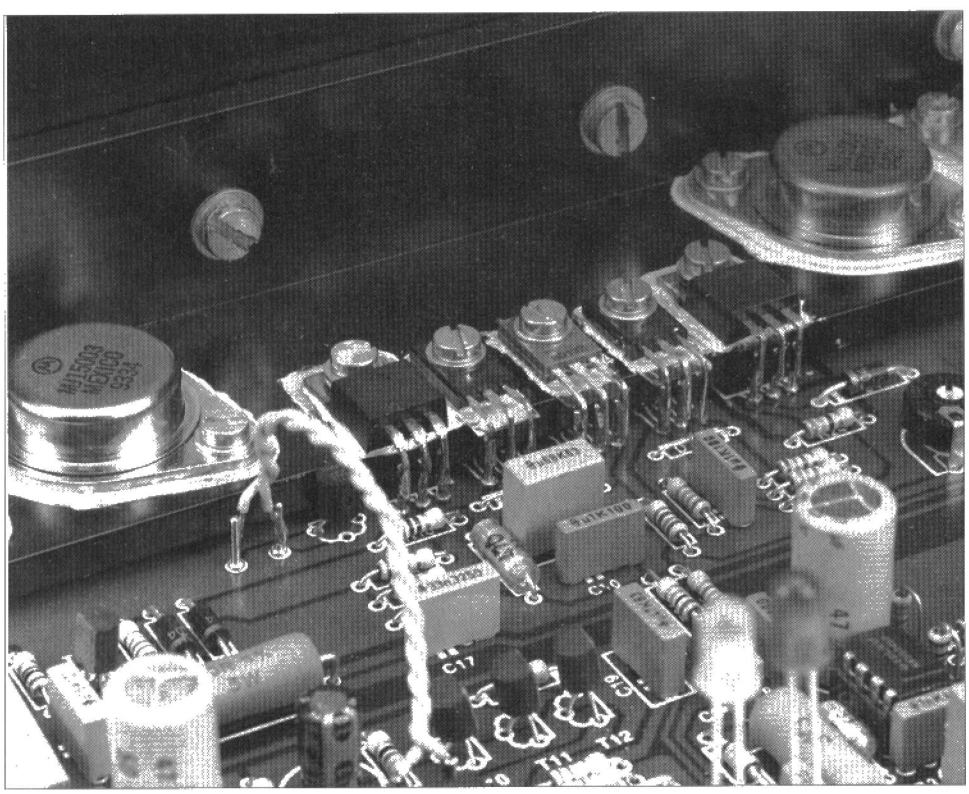


Fig. 3. This close-up photograph shows clearly how the transistors are fitted to the heat sink via a rectangular bracket.

of D_{13}.

Strictly speaking, temperature protection is not necessary, but it offers that little bit extra security. The temperature sensor is R_{39}, a PTC (positive temperature coefficient) type, which is located on the board in a position where it rests against the rectangular bracket. Owing to a rising temperature, the value of R_{39} increases until the potential at the –ve input of IC_{2a} rises above the level at the +ve input set by divider R_{45}-R_{46}, whereupon the output of IC_{2a} goes low. This causes IC_{2b} to change state, whereupon T_{13} is cut off and the relay is deenergized. This time, the situation is indicated by the lighting of D_{14}. The circuit has been designed to operate when the temperature of the heat sink rises above 70 °C. Any relay clatter may be obviated by reducing the value of R_{48}.

The terminal marked 'CLIP' on the PCB is connected to the output of IC_1 via R_{31}. It serves to obtain an external overdrive indication, which may be a simple combination of a comparator and LED. Normally, this terminal is left open.

Power supply

As with most power amplifiers, the ±60 V power supply need not be regulated. Owing to the relatively high power output, the supply needs a fairly large mains transformer and corresponding smoothing capacitors—see **Fig. 2**. Note that the supply shown is for a mono amplifier; a stereo outfit needs two supplies.

The transformer is a 625 VA type, and the smoothing capacitors are 10 000 µF, 100 V electrolytic types. The bridge rectifier needs to be mounted on a suitable heat sink or be mounted directly on the bottom cover of the metal enclosure.. The transformer needs two secondary windings, providing 42.5 V each. The prototype used a toroidal transformer with 2×40 V secondaries. The secondary winding of this type of transformer is easily extended: in the prototype 4 turns were added and this gave secondaries of 2×42.5 V.

The box 'Mains power-on delay' provides a gradual build-up of the mains voltage, which in a high-power amplifier is highly advisable. A suitable design was published in *305 Circuits* (page 115).

The relay and associated drive circuit is intended to be connected to terminal 'AC' on the board, where it serves to power the power-on circuit. If a slight degradation of the amplifier performance is acceptable, this relay and circuit may be omitted and the PCB terminal connected directly to one of the transformer secondaries.

Construction

Building the amplifier is surprisingly simple. The printed-circuit board in **Fig. 4** is well laid out and provides ample room. Populating the board is as usual best started with the passive components, then the electrolytic capacitors, fuses and relay. There are no 'difficult' parts.

Circuits IC_1 and IC_2 are best mounted in appropriate sockets.

Diodes D_{13} and D_{14} will, of course, have to be fitted on the front panel of the enclosure and are connected to the board by lengths of flexible circuit wire.

Inductor L_1 is a DIY component; i consists of 15 turns of 1 mm. dia. enamelled copper wire around R_{29} (not too tight!).

Since most of the transistors are to be mounted on and the same heat sink, they are all located at one side of the board. However, they should first be fitted on a rectangular bracket, which is secured to the heat sink and the board—see **Fig. 3**. Note that the heat sink shown in this photograph proved too small when 4 Ω loudspeakers were used. With 8 Ω speakers, it was just about all right, but with full

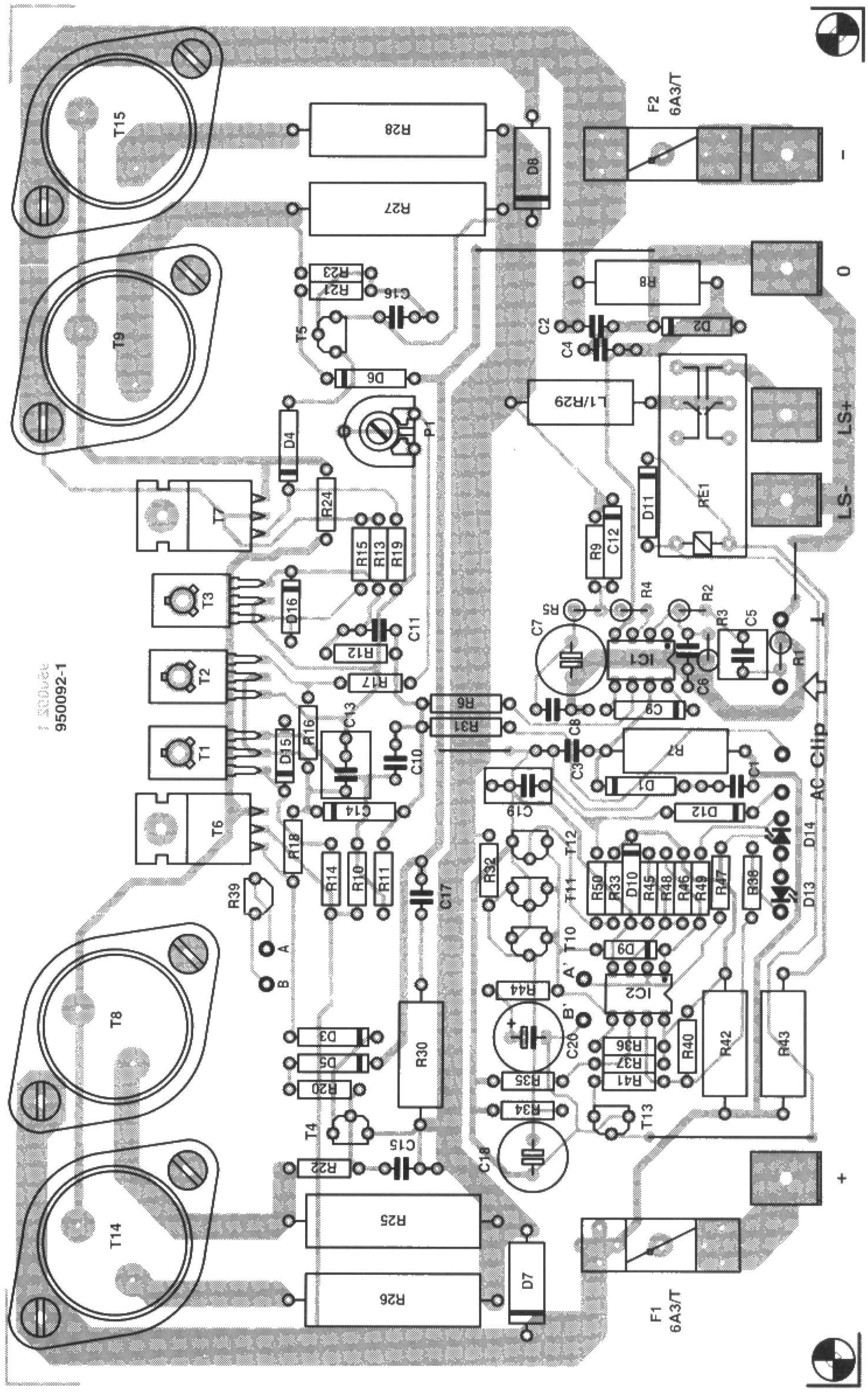


Fig. 4a. Component layout of the printed-circuit board for the 300 W power amplifier.

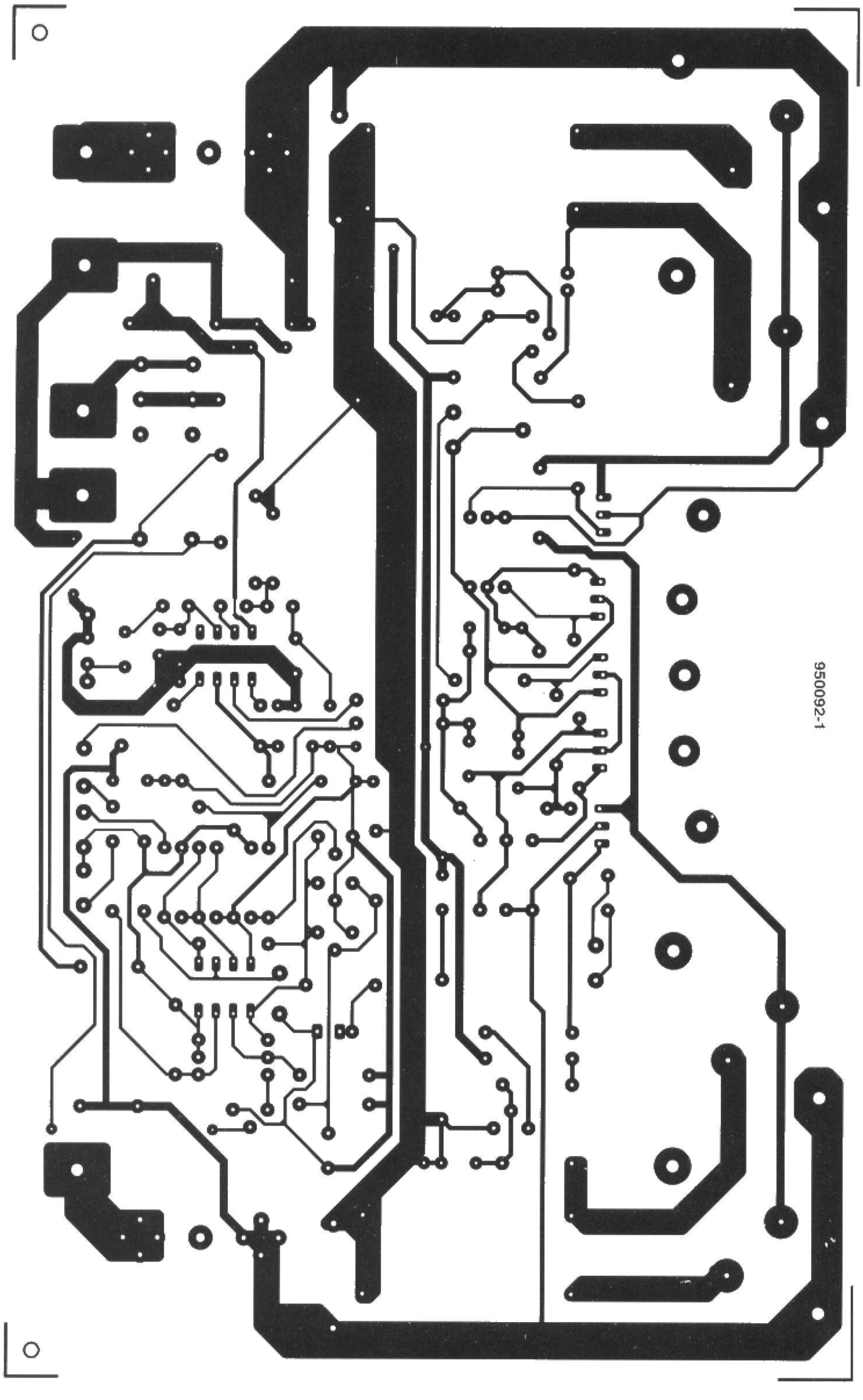


Fig. 4b. Track layout of the printed-circuit board for the 300 W power amplifier.

drive over sustained periods, the temperature protection circuits were actuated. If such situations are likely to be encountered, forced cooling must be used.

As already stated, temperature sensor R_{39} should rest (with its flat surface) against the rectangular bracket. On the board, terminals 'A' and 'B' terminals to the left of R_{39} must be connected to 'A' and 'B' above IC_2 with a twisted pair of lengths of insulated circuit wire as shown in Fig. 3.

The points where to connect the loudspeaker leads and power lines are clearly marked on the board. Use the special flat AMP connectors for this purpose: these have large-surface contacts that can handle large currents. The loudspeaker cable should have a cross-sectional area of not less than 2.5 mm^2.

Finally

How the amplifier and power supply are assembled is largely a question of individual taste and requirement. The two may be combined into a mono amplifier, or two each may be built into a stereo amplifier unit. Our preference is for mono amplifiers, since these run the least risk of earth loops and the difficulties associated with those. It is advisable to make the '0' of the supply the centre of the earth connections of the electrolytic capacitors and the centre tap of the transformer.

The single earthing point on the supply and the board must be connected to the enclosure earth by a short, heavy-duty cable. This means that the input socket must be an insulated type. This socket must be linked to the input on the board via screened cable.

To test the amplifier, turn P_1 fully anticlockwise and switch on the mains. After the output relay has been energized, set the quiescent current. This is done by connecting a multimeter (direct mV range) across one of resistors R_{25}–R_{28} and adjusting P_1 until the meter reads 27 mV (which corresponds to a current of 100 mA through each of the four power transistors). Leave the amplifier on for an hour or so and then check the voltage again: adjust P_1 as required.

Test results

The technical data given on page**00** were verified or obtained with a power supply as shown in Fig. 2. They show that in spite (or because?) of its simple design, the amplifier offers excellent performance. The distortion figures are particularly good.

Measurements with the Audio Precision analyser are illustrated in **Fig. 5**.

Figure 5a shows the total harmonic distortion (THD+N) over a frequency range of 20 Hz to 20 kHz.with a bandwidth of 80 kHz and a power output of 150 W into 8 Ω. Up to 1 kHz, the distortion is very low and then increases, which is usual and caused by the inertia of the semiconductors.

Figure 5b shows the distortion at 1 kHz as a function of the output level at a bandwidth of 22 Hz to 22 kHz. The dashed curve refers to a load of 4 Ω and the solid curve to a load of 8 Ω. The irregularities between 10 W and 100 W are not caused by the amplifier but by the limits of the measuring range of the analyser. From the clipping points, the curves rise almost vertically.

Figure 5c shows the maximum for a distortion of 0.1%. The dashed curve (4 Ω load) is very close to the 300 W line. The small reduction at low frequencies is caused by the imperfectness of the electrolytic buffer capacitors in the power supply.

Figure 5d shows the Fourier analysis of a 1 kHz signal for a power out-

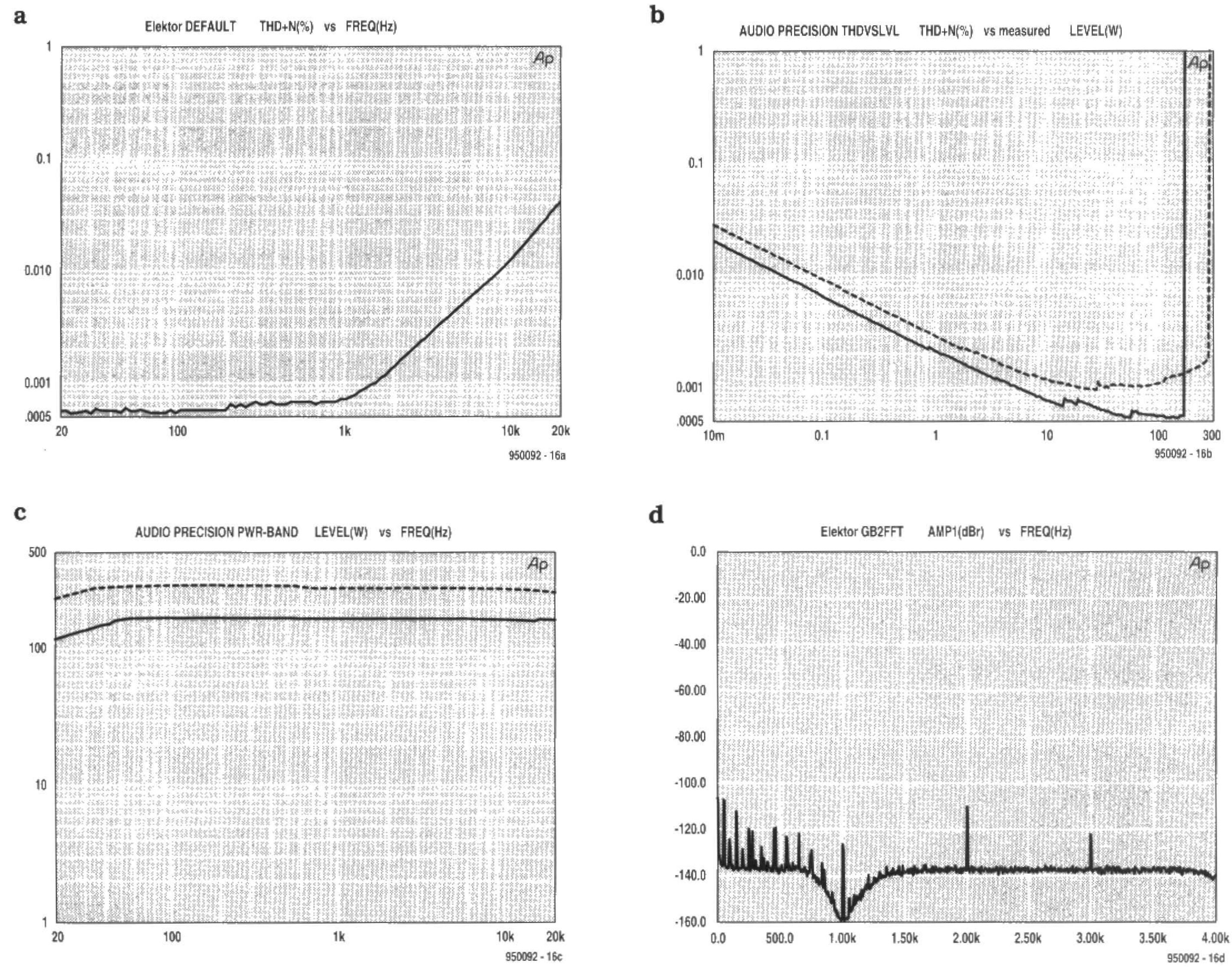


Fig. 5. Curves obtained during measurements on the amplifier with an Audio Precision Analyser (see text).

put of 1 W into 8 Ω. The fundamental frequency is suppressed. The 2nd and 3rd harmonics are down by 110 dB and 120 dB respectively referred to the fundamental frequency. The THD+N figure at this measurement was 0.0009%.

Parts list

Resistors:
R_1 = 68 kΩ
R_2 = 2.2 kΩ
R_3, R_9 = 22 kΩ
R_4, R_{22}, R_{23} = 1 kΩ
R_5, R_6, R_{10}, R_{13} = 560 Ω
R_7, R_8, R_{42} = 3.3 kΩ, 5 W
R_{11}, R_{12}, R_{37} = 15 kΩ
R_{14}, R_{15} = 150 Ω
R_{16} = 680 Ω
R_{17} = 180 Ω
R_{18}, R_{19} = 10 Ω
R_{20}, R_{21}, R_{46}, R_{47} = 27 kΩ
R_{24} = 56 Ω
R_{25}–R_{28} = 0.27 Ω, 5 W
R_{29} = 2.2 Ω, 5 W
R_{30} = 10 Ω, 5 W
R_{31} = 10 kΩ
R_{32}, R_{34} = 100 kΩ
R_{33} = 47 kΩ
R_{35} = 1.5 kΩ
R_{36} = 470 kΩ
R_{38}, R_{49} = 3.3 kΩ
R_{39} = sensor Type KTY81-122
R_{40} = 4.7 kΩ
R_{41} = 33 kΩ
R_{43} = 1.5 kΩ, 5 W
R_{44} = 47 Ω
R_{45} = 1.40 kΩ, 1%
R_{48} = 1 MΩ
R_{50} = 120 kΩ
P_1 = 250 Ω preset

Capacitors:
C_1–C_4, C_8, C_{10}, C_{11} = 100 nF
C_5 = 2.2 µF polypropylene, pitch 5 mm
C_6 = 1 nF
C_7, C_{18} = 47 µF, 50 V, bipolar, radial;
C_9 = 33 pF, 160 V, polystyrene
C_{12} = 47 pF, 160 V, polystyrene
C_{13} = 680 nF
C_{14} = 470 pF, 160 V, polystyrene
C_{15}, C_{16} = 150 nF
C_{17} = 33 nF
C_{19} = 470 nF
C_{20} = 47 µF, 25 V, radial

Semiconductors:
D_1, D_2, D_{10} = zener, 15 V, 1.5 W
D_3, D_6, D_{12} = 1N4004
D_7, D_8 = BY254
D_9 = 1N4148
D_{11} = 1N4002
D_{13}, D_{14} = LED
D_{15}, D_{16} = BAT85
T_1 = MJE350
T_2 = BD139
T_3 = MJE340
T_4 = BC546B
T_5 = BC556B
T_6 = MJE15030
T_7 = MJE15031
T_8, T_{14} = MJ15003
T_9, T_{15} = MJ15004
T_{10}, T_{12} = BC337
T_{13} = BC639

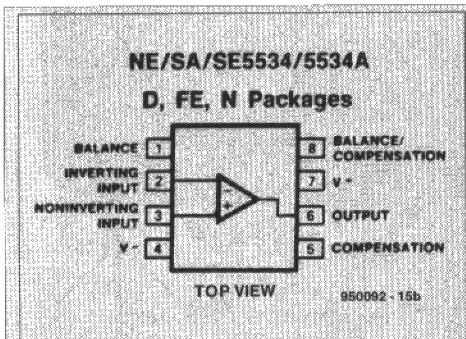
Integrated circuits:
IC_1 = NE5534
IC_2 = LM393

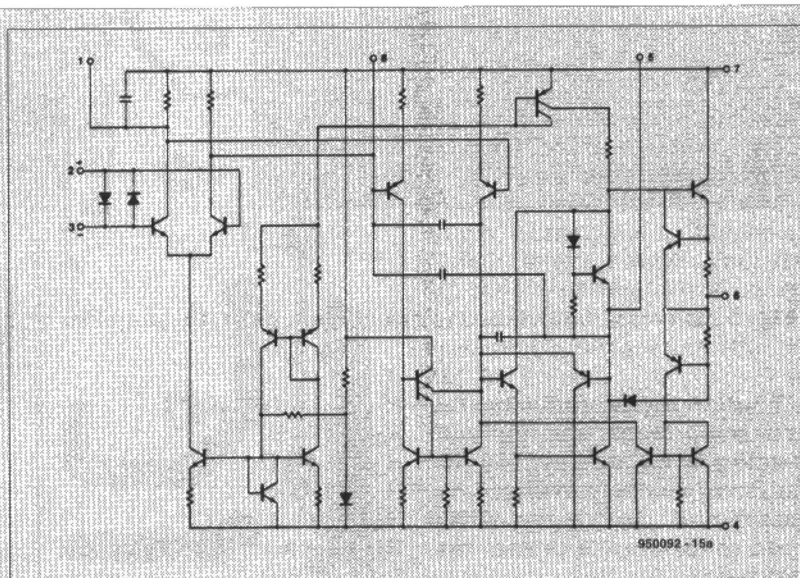
Miscellaneous:
L_1 = see text
Re_1 = 16 A, 24 V, 875 Ω relay (e.g. Siemens V23056-AO105-A101*)

F_1, F_2 = glass fuse, 6.3 A, slow complete with PCB type holder
Loudspeaker and mains connectors for board mounting (AMP - see text)
Mica washers for T_1–T_3, T_6–T_9, T_{14} and T_{15}
Rectangular bracket e.g. SWP40, 20 cm long (Fischer 40×30×5**)
Heat sink <0.4 K W^{-1}
PCB Order no. 950092
Mains transformer, 2×42.5 V, 625 VA (see text)
Fuse (power supply) 3.15 A, slow, $I^2t \geq 400$
Bridge rectifier 400 V, 35 A
4 off electrolytic capacitors, 10,000 μF, 100 V
PCB Order No. 924055

[950092]

* ElectroValue 01784 33603 or 0161 432 4945
** Dau 01243 553 031; trade only, but information on your nearest dealer will be given by telephone.





The NE5534

The NE5534 is a good quality, versatile, low-noise operational amplifier which is excellent value for money.

Compared with older types, it has better noise figures, small signal performance, power bandwidth, and output drive capability.

These characteristics make it ideally suited to high-end audio applications. It is found even in the most expensive CD players.

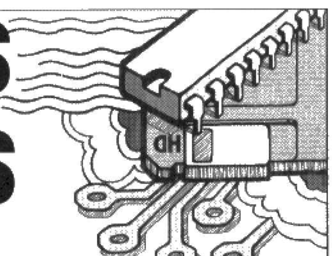
The adjacent simplified diagram gives an idea of the internal structure of this versatile device. It consists of a number of differential amplifiers that are set with the aid of current sources and current mirrors. Well-designed compensation circuits result in excellent linearity and very low distortion.

The standard design gives an amplification of ×3. The frequency response can be optimized for various applications with the aid of an external capacitor. It may be adjusted for a capacitive load, high slew rate, low overshoot or for application as a unity amplifier.

Some technical data

Small-signal bandwidth	10 MHz
Output voltage (at $U_b = \pm 18$ V)	10 V_{rms} across 600 Ω
Input noise	4 nV Hz^{-1}
DC voltage amplification	10^5
AC voltage amplification	6×10^3 at 10 kHz
Power bandwidth	200 kHz
Slew rate	13 V μs^{-1}
Supply voltage range	±3 V to ±20 V

READERS SERVICES



NOVEMBER 1995

GENERAL

Ready-made printed-circuit boards (PCBs), self-adhesive front panel foils, ROMs, EPROMs, PALs, GALs, microcontrollers and diskettes for projects which have appeared in *Elektor Electronics* may be ordered using the order form printed opposite. The form may also be used to order books (private customers only).

- Items marked with a dot (•) following the product number are in limited supply only, and their availability can not be guaranteed by the time your order is received.
- Items not listed here are not available.
- The artwork for making PCBs which are not available ready-made through the Readers Services may be found in the relevant article (from March 1990 onwards).
- EPROMs, GALs, PALs, PICs and other microcontrollers are supplied ready-programmed.
- Prices and item descriptions subject to change. The publishers reserve the right to change prices without prior notification. Prices and item descriptions shown here supersede those in previous issues. E. & O.E.

ORDERING INSTRUCTIONS, P&P CHARGES

Except in the USA and Canada, all orders, except for subscriptions and past issues (for which see below), must be sent BY POST to our Dorchester office using the Order Form opposite. Please note that we can not deal with PERSONAL CALLERS, as no stock is carried at the editorial and administrative office.

Readers in the USA and Canada should send orders, except for subscriptions (for which see below), to Old Colony Sound Lab, Peterborough NH, whose full address is given on the order form opposite. Please include shipping cost according to total order value. For surface delivery in the USA, if order is less than \$50, include \$3; \$50+, \$4. For Canada surface, if less than US\$50, include US\$5; US\$50+, US\$7.50. For air or other deliveries, please inquire. Please allow 4-6 weeks for delivery.

All other customers must add postage and packing charges for orders up to £25.00 as follows: UK and Eire £1.95; surface mail outside UK £2.45; Europe (airmail) £2.95; outside Europe (airmail) £3.70. For orders over £25.00, but not exceeding £100.00, these p&p charges should be doubled. For orders over £100.00 in value, p&p charges will be advised.

HOW TO PAY

Unless you have an approved credit account with us, all orders must be accompanied by the full payment, including postage and packing charges as stated above.

Payment may be made by cheque **drawn on a London clearing bank** (but see para. 4 below), postal order, VISA, Access, MasterCard or EuroCard (when paying by credit card, the order must go the cardholder's address). Do not send cash through the mail. Cheques and postal orders should be crossed and made payable to 'Elektor Electronics (Publishing)'.

Payment may also be made by direct transfer from a private or business Giro account to our **Giro account No. 34 152 3801** by completing and sending to the National Giro Centre, in a National Giro postage paid envelope, a National Giro transfer/deposit form. Do not send Giro transfers direct to us, as this will delay your order.

If you live outside the UK, payment may also be made by Bankers' sterling draft **drawn on a London clearing bank**, **Eurocheque** made out in pounds sterling (with holder's guarantee card number written on the back), or US or Canadian dollar cheque, but such cheques, accepted at the exchange rate prevailing at the time your order is received, **must be increased by the equivalent of £15.00** to cover our bankers' negotiating fee.

If you pay by Bankers' sterling draft, make clear to the issuing bank that your full name and address MUST be communicated to the London clearing bank.

Our bankers are **National Westminster Bank, 49 South Street, DORCHESTER, Dorset DT1 1DW, England**. Our account number is **6966 3340**.

SUBSCRIPTIONS & PAST ISSUES

Subscriptions and past issues, if available, should be ordered from **Worldwide Subscription Service Ltd, Unit 4, Gibbs Reed Farm, Pashley Road, TICEHURST TN5 7HE, England.** For subscriptions, use the subscriptions order form elsewhere in this magazine.

Prices of past issues (except July/August and December), including postage for single copies, are £2.70 (UK and Eire); £3.00 (surface mail outside UK); £3.20 (air mail Europe); £3.95 (airmail outside Europe). Prices of past July/August and December issues, including postage for single copies, are £3.75 (UK); £4.00 (surface mail outside UK); £4.25 (airmail Europe); and £5.00 (airmail outside Europe).

PAST ARTICLES

For information on past articles, please contact our Editorial and Administrative Office at Dorchester (telephone 01305 250995; fax 01305 250996).

COMPONENTS

Components for projects appearing in *Elektor Electronics* are usually available from appropriate advertisers in this magazine. If difficulties in the supply of components are envisaged, a source will normally be advised in the article. It should be noted that the source(s) given is (are) not exclusive — other suppliers may also be able to help.

TERMS OF BUSINESS

Delivery Although every effort will be made to dispatch your order within 2-3 weeks from receipt of your instructions, we can not guarantee this time scale for all orders.

Returns Faulty goods or goods sent in error may be returned for replacement or correction, but not before obtaining our consent. All goods returned should be packed securely in a padded bag or box, enclosing a covering letter stating the dispatch note number. If the goods are returned because of a mistake on our part, we will refund the return postage. Goods returned for refund must be in resaleable condition and will be subject to a 10% handling charge with a minimum charge of £2.50.

Damaged goods Claims for damaged goods must be received at our Dorchester office within 10 days (UK); 14 days (Europe) or 21 days (all other countries) from the date on our 'Recorded delivery' slip.

Cancelled orders All cancelled orders will be subject to a 10% handling charge with a minimum charge of £2.50.

Patents Patent protection may exist in respect of circuits, devices, components, and so on, described in our books and magazines. Elektor Electronics (Publishing) do not accept responsibility or liability for failing to identify such patent or other protection.

Copyright All drawings, photographs, articles, printed circuit boards, programmed integrated circuits, diskettes and software carriers published in our books and magazines (other than in third-party advertisements) are copyright and may not be reproduced or transmitted in any form or by any means, including photocopying and recording, in whole or in part, without the prior permission of Elektor Electronics (Publishing) in writing. Such written permission must also be obtained before any part of these publications is stored in a retrieval system of any nature.

Notwithstanding the above, printed-circuit boards may be produced for private and personal use without prior permission.

Limitation of liability Elektor Electronics (Publishing) shall not be liable in contract, tort, or otherwise, for any loss or damage suffered by the purchaser whatsoever or howsoever arising out of, or in connexion with, the supply of goods or services by Elektor Electronics (Publishing) other than to supply goods as described or, at the option of Elektor Electronics (Publishing), to refund the purchaser any money paid in respect of the goods.

Law Any question relating to the supply of goods and services by Elektor Electronics (Publishing) shall be determined in all respects by the laws of England.

July 1995

Article title	Order no.	Price (£)	(US\$)
NOVEMBER 1995			
Elektor Item Tracer 1985-1994	*see advert in this issue*		
PIP Processor:			
- PCB + 87C51 (956505-1)	950078-C	54.75	109.50
- 87C51	956505-1	30.75	61.50
FM noise squelch	950089-1	10.75	21.50
PA 300 power amplifier	950092-1	19.75	39.50
Jogging LED	950112-1	7.00	14.00
Oscilloscope prescaler	950115-1	27.75	55.50
Symmetrical supply in cars		*Not available*	
3.3-15V power supply	950106-1	9.25	18.50
OCTOBER 1995			
Elektor Item Tracer 1985-1994	*see advert in this issue*		
MatchBox BASIC computer:			
- PCB, 87C51 (956508-1) and Quick Reference Card	950011-C	45.75	91.50
- 87C51	956508-1	32.25	64.50
- Course diskette (DOS)	956009-1	10.75	21.50
Special Autumn Supplement:			
- Experimentation board for PICs, incl. free disk for *PLC Emulaton Using PIC Micro-controllers*	944105-1	17.75	35.50
SEPTEMBER 1995			
Elektor Item Tracer 1985-1994	*see advert in this issue*		
Hi-Fi headphone amplifier	950064-1	5.00	10.00
Dongle safe:			
- PCB	950069-1	12.75	25.50
- GAL IC2 (20V8)	956511-1	10.00	20.00
- GAL IC6 (22V10)	956512-1	11.75	23.50
HexFET power amp upgrade:			
- amplifier PCB	930102	12.75	25.50
- power-on delay PCB	924055	6.45	12.90
Copybit eliminator update:			
- PCB + MACH (956504-1)	950084-C	40.50	81.00
- MACH IC	956504-1	36.50	73.00
RF tone-dip oscillator	950095-1	5.25	10.50
JULY/AUGUST 1995			
Active mini subwoofer	936047	12.25	24.50
Mini robot car	936069	8.00	16.00
Simple RF function generator	950023-1	7.50	15.00
Alkali/Manganese battery charger	950056-1	6.75	13.50
Fast charger for NiCd batteries:			
- PCB + ST62T20 (956509-1)	950076-C	22.75	45.50
- ST62T20	956509-1	14.75	29.50
Simple I/O card	954074-1	11.50	23.00
6-V motive battery charger	940083-1	7.25	14.50
JUNE 1995			
Function generator:			
- PCB	950068-1	29.50	59.00
- Front panel foil	950068-F	17.75	35.50
Electronic sandglass:			
- PCB + 87C751 (946647-1)	950052-C	26.25	52.50
- 87C751	946647-1	17.75	35.50
Auto light control	950050-1	4.75	9.50
VGA distribution amplifier	950017-1	10.00	20.00
MAY 1995			
MIDI analyser:			
- PCB + EPROM (956507-1)	940020-C	34.25	68.50
- EPROM	956507-1	16.75	33.50
Programmer for 87/89C51 series Flash controllers:			
- PCB + EPROM (956644-1)	950003-C	26.50	53.00
- EPROM	946644-1	14.50	29.00
Programmable sine wave generator:			
- PCB + disk (956005-1)	950004-C	19.50	39.00
- control software on disk	956005-1	12.25	24.50
NiCd battery-quality tester:			
- PCB + ST62T15 (956506-1)	950051-C	25.25	50.50
- ST62T15	956506-1	18.25	36.50
APRIL 1995			
Electronic barometer	936033	8.50	17.00
Bat detector	936046	10.25	20.50
Sun blind control	950035-1	9.25	18.50
Function generator:			
- PCB + front panel foil	950044-C	21.75	43.50
- PCB	950044-1	11.00	22.00
- Front panel foil	950044-F	12.50	25.00
Stepper motor control:			
- PCB + 8751 + disk	950038-C	50.75	101.50
- 8751	956503-1	35.25	70.50
- test program on PC disk	956004-2	3.75	7.50
MARCH 1995			
Telephone-controlled mains switch:			
- PCB + PIC (946642-1)	950010-C	22.00	44.00
- PIC 16C54	946642-1	17.50	35.00
DSP function generator:			
- PCB + disk (956001-1) + EPROM (956501-1)	950014-C	49.00	98.00
- EPROM 27C512	956501-1	13.25	26.50
- software on IBM PC disk	956001-1	18.50	37.00
- Windows program manual	950014-P	7.50	15.00
TDA1560Q car audio amplifier	950024-1	9.50	19.00
FEBRUARY 1995			
MIDI multiplexor	930101	15.00	30.00
Automatic lighting timer	940098-1	10.75	21.50
Infrared dimmer	940109-1	9.75	19.50
Light-effects generator	940100-1	6.50	13.00
Upgrade your car battery charger	940111-1	7.00	14.00
Surround sound processor	950012-1	18.75	37.50
Induction motor governor	940095-1	7.50	15.00
JANUARY 1995			
Mini Audio DAC	940099-1	14.75	29.50

Article title	Order no.	Price (£)	(US\$)
1-to-3-phase converter:			
- PCB + GAL + EPROM	940077-C	52.75	105.50
- GAL	946640-1	12.25	24.40
- EPROM	946640-2	15.75	31.50
P.O.S.T. diagnostic card:			
- PCB + GALs (946639-1/2)	950008-C	29.25	58.50
- GAL-1	946639-1	11.00	22.00
- GAL-2	946639-2	13.00	26.00
Self-loading EEPROM type X88C64 SLIC	940116-1	8.25	16.50
Debugging 8031/8051 microcontroller systems:			
- PCB + disk (946203-1)	940117-C	15.00	30.00
- software on IBM PC disk	946203-1	11.50	23.00
Quasi-analogue clockwork	930024	37.25	74.50
DECEMBER 1994			
In-car audio amplifier (3)	940078-2	30.25	60.50
RF immune power supply	940054-1	9.00	18.00
ispStarter kit from Lattice:			
- PCB + disk (946204-1)	940093-C	21.50	43.00
- Examples on PC disk	946204-1	9.75	19.50
NOVEMBER 1994			
Single-wire communication	940055-1	4.00	8.00
In-car audio amplifier (2)	940078-2	30.25	60.50
Solid-state disk:			
- PCB + EPROM (946641-1)	940085-C	47.50	95.00
- EPROM 27256	946641-1	23.50	47.00
Simple capacitance meter	940091-1	10.00	20.00
OCTOBER 1994			
Motive-battery charger	940083-1	7.25	14.50
Integrated AF amplifier:			
- output amplifier board	936062-1	9.50	19.00
- preamplifier PCB	936062-2	28.25	56.50
Tester for IR remote control	940084-1	6.50	13.00
In-car audio amplifier (1)	940078-1	14.00	28.00
TV line monitor:			
- PCB + PIC (946643-1)	940065-C	26.25	52.50
- PIC 16C54	946643-1	20.25	40.50
SEPTEMBER 1994			
Switchable a.c. supply	934004	6.50	13.00
Anemometer & flow meter	940017	6.25	12.50
Compact frequency meter	940051-1	9.00	18.00
Revolution counter			
- sensor board (option)	940045-1	6.00	12.00
- main board	940068-1	5.50	11.00
JULY/AUGUST 1994			
General purpose IR volume control	930099	9.00	18.00
IR controlled switch	936066	9.75	19.50
MIDI swell pedal:			
- PCB + EPROM (946635-1)	940019-C	26.75	53.50
- EPROM 27C64	946635-1	13.75	27.50
Charge meter	940033-1	5.75	11.50
Water softener	944011-1	6.00	12.00
Joystick-to-mouse adaptor	944040-1	7.00	14.00
Discrete preamplifier	944063-1	8.50	17.00
Centronics I/O interface	944067-1	8.75	17.50
80C451 controller board	944069-1	15.00	30.00
Robust AF power amp	944075-1	9.75	19.50
PC over-temperature alarm	944076-1	4.25	8.50
1-4 MByte SIMM adaptor	944094-1	15.50	31.00
Optical doorbell	944080-1	6.25	12.50
PIC experimenting board	944105-1	17.75	35.50
RC5 transmitter with 80C535:			
- PCB + disk (946199-1)	944106-C	13.00	26.00
- software on IBM PC disk	946199-1	9.75	19.50
Small loop antennas:			
- software on IBM PC disk	1951	10.75	21.50
Software emulation of RC5 infra-red code:			
- software on IBM PC disk	1901	10.75	21.50
PIC programming course:			
- files and misc. utilities on IBM PC disk	946196-1	9.75	19.50
JUNE 1994			
80C535 SBC extension:			
- PCB	940025-1	19.75	39.50
- software on IBM PC disk	1941	9.75	19.50
- I²C display software on IBM PC disk	946197-1	9.75	19.50
I²C bus booster	940057-1	7.25	14.50
RS485 interface	940035-1	6.25	12.50
Fuel consumption monitor	940045-1	6.00	12.00
Intelligent EPROM eraser	940058-1	9.00	18.00

Elektor Electronics books

How to build your own Electronic Test Instruments	£15.95	\$29.50
How to build your own AF valve amplifiers	£14.95	\$28.00
Short course 8051/8032 Microcontrollers and Assembler	£9.95	\$18.50
SMT projects	£9.95	\$18.50
301 Circuits	£9.95	\$18.50
302 Circuits	£9.95	\$18.50
303 Circuits	£10.95	\$20.25
304 Circuits	£12.95	\$23.95
305 Circuits	£14.95	\$27.70
Microprocessor Data Book	£10.95	\$20.25
Data Sheet Book 2	£9.95	\$18.50
Data Book 3: Peripheral Chips	£10.95	\$20.25

Please send this order form to *
Elektor Electronics (Publishing)
P.O. Box 1414
Dorchester DT2 8YH
ENGLAND
Tel. (01305) 250995
Fax (01305) 250996

* *USA and Canada residents only:* use $ prices, and send order form to:
Old Colony Sound Lab, P.O. Box 243, Peterborough, NH 03458.
Tel. (603) 924-6371, 924-6526, Fax: (603) 924-9467

ORDER FORM

11-95

VAT No.GB 454 135 463

Name

Address

Post code

Tel. Fax Date

Please supply the following. For PCBs, front panel foils, EPROMs, PALs, GALs, microcontrollers and diskettes, state the part number and description; for books, state the full title; for photocopies of articles, state full name of article and month and year of publication. Please use block capitals.

Qty.	Order Code	Description	Price each	Total
			Sub-total	
			P&P	
			Total paid	

Method of payment (see opposite before ticking as appropriate)
Note: cheques not made out in sterling must be increased by the equivalent of £15.00

❑ Bank draft ❑ Cheque (payable to Elektor Electronics Publishing)

❑ Giro transfer (our account no. 34 152 3801)

❑ Postal/money order

❑ VISA Access MasterCard Eurocard

Expiry date:

Signature:

Article title	Order no.	Price (£)	Price (US$)
MAY 1994			
Mains signalling system - 2:			
- transmitter PCB, disk (1911) and EPROM (6371)	940021-2C	33.25	66.50
- EPROM 27C64	6371	13.25	26.50
- software on IBM PC disk	1911	9.75	19.50
APRIL 1994			
Mains signalling system - 1:			
- receiver board	940021-1	10.25	20.50
68HC11 processor board	930123	7.75	15.50
Headphones amplifier	940016	18.75	37.50
MARCH 1994			
80C535 assembler course:			
- EMON52 ROM + disk (1811)	6221	17.05	34.10
- disk (IBM PC format)	1811	8.80	17.60
PIC programmer:			
- PCB + software set (7161)	940048-C ●	66.00	132.00
- PIC17C42 + PC disk	7161	52.75	105.50
100W AF amplifier			
- adaptor board	930039	8.25	16.50
- amplifier board	920135-1	19.40	38.80
- protection board	920135-2	7.95	15.90
FEBRUARY 1994			
80C535 single-board computer	924046	14.10	28.20
Copybit eliminator:			
- PCB + MACH + GAL	930098-C ●	46.25	92.50
- MACH + GAL	6321	42.25	84.50
Mini preamplifier	930106	29.25	58.50
Bidirectional RS232-to-Centronics converter	930134	14.00	28.00
JANUARY 1994			
SIM — an 8051 simulator:			
- software on IBM PC disk	1931	34.25	68.50
Digital dial	920161	12.75	25.50
RDS decoder:			
- PCB + EPROM (6331)	930121-C	23.75	51.50
- EPROM 27C64	6331	14.50	29.00
I^2C tester:			
- PCB + GAL (6341)	930128-C	36.25	72.50
- GAL type 6001	6341	30.75	61.50
Telephone-controlled switch:			
- PCB + EPROM (6271)	934054-C	37.25	74.50
- EPROM 2764	6271	14.50	29.00
DECEMBER 1993			
535 card with EPROM emulator:			
- GAL and PAL	6311	26.00	52.00
RMS AF voltmeter:			
- PCB	930108	12.25	24.50
- front panel foil	930108-F	17.25	34.50
I^2C power switch	930091	6.25	12.50
Medium power HEXFET amplifier	930102	12.75	25.50
Microcontroller-driven UART:			
- PCB	930073	4.75	9.50
- ST62T10	7151	17.25	34.50
SCART switching box	930122	14.25	28.50
NOVEMBER 1993			
Precision clock for PCs:			
- PCB + disk (1871)	930058-C	12.25	24.50
- software on IBM Pc disk	1871	8.50	17.00
VHF/UHF TV tuner			
- PCBs -1 and -2, and µC 87C51 (7141)	930064-C	57.25	114.50
- µC 87C51	7141	25.75	51.50
Output amplifier with AF bandpass filter	930071	6.75	13.50
Digital hygrometer:			
- PCB + EPROM (6301)	930104-C	28.00	56.00
- EPROM 2764	6301	14.50	29.00
Power MOSFET tester	930107	32.50	65.00
OCTOBER 1993			
Stereo mixer	UPBS-1	1.95	3.90
MIDI channel monitor	930059	14.00	28.00
Ah meter with digital display	930068	14.00	28.00
Autoranging frequency readout	930034	12.50	25.00
ROM-gate switchover for Atari ST	930005	30.25	60.50
Microntroller-driven NiCd battery charger			
- board and ST62E15	920162-C	25.50	51.00
- ST62E15	7071	10.00	20.00
Fuzzy logic multimeter - 2:			
- PCB + Fuzzy Control One	920049-C	23.75	47.50
- Fuzzy Control One disk	1721	7.75	15.50
SEPTEMBER 1993			
Fuzzy logic multimeter -1	920049-2	20.00	40.00
Linear temperature gauge	920150	7.05	14.10
PC-aided transistor tester:			
- PCB	920144	9.75	19.50
- software on IBM PC disk	1781	7.50	15.00
Harmonic enhancer	930025	13.50	27.00
I^2C alphanumerical display:			
- PCB + disk (1851)	930044-C	14.25	28.50
- Software on IBM PC disk	1851	8.50	17.00
Mini micro clock			
- PCB	930055	7.50	15.00
- clock: ST62T15	7111	11.50	23.00
- darkroom timer: ST62T15	7121	11.50	23.00
- cooking timer: ST62T15	7131	11.50	23.00
950-1750 MHz converter	UPBS-1	1.95	3.90
JULY/AUGUST 1993			
Active 3-way loudspeaker system	930016	21.50	43.00
Maxi micro clock			
- PCB	930020	15.50	31.00
- clock: ST62T10	7081	11.50	23.00
- darkroom timer: ST62T10	7091	11.50	23.00
- cooking timer: ST62T10	7101	11.50	23.00
SMD soldering station	930065	9.50	19.00
VHF-low converter	926087	15.50	31.00
I^2C bus fuse (5 on 1 PCB)	934016	8.00	16.00
Voice operated recording	934039	6.00	12.00
General transformer PCB	934004	6.50	13.00
Plant humidity monitor	934031	4.50	9.00
Plant humidity monitor (supply)	934032	4.00	8.00
Four-fold DAC card for PCs:			
- GAL	6251	10.75	21.50
Multi-purpose display decoder:			
- EPROM 27128	6261	11.50	23.00
JUNE 1993			
Spectrum VU meter	920151	13.00	26.00
GAL programmer upgrade:			
- PCB	930060	4.50	9.00
- software on IBM PC disks	1701	11.15	22.30
- idem. w/o Opal Jr. disks	1881	10.75	21.50
- software on Amiga disk	1841	11.00	22.00
Digital frequency readout for VHF/UHF receiver	926001-2	11.50	23.00
Inexpensive phase meter:			
- main board	930046	9.00	18.00
- meter board	920018	4.70	9.40
- front panel foil	930046-F	17.25	34.50
X2404-to-8751 interfacing:			
- software on IBM PC disk	1891	8.50	17.00
MAY 1993			
FM stereo signal generator	920155	23.00	46.00
VHF/UHF receiver	926001	19.00	38.00
Philips preamplifier:			
- PCB	930003	7.50	15.00
- software on IBM PC disk	1861	8.50	17.00
Workbench PSU:			
- main PCB	930033	21.50	43.00

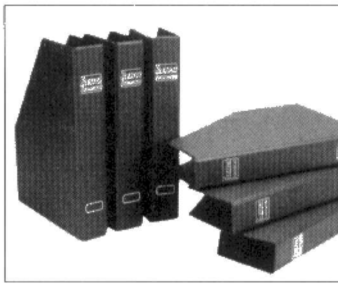
continued overleaf

Looking for clues? Can't find it? **E·I·T**

***Elektor Electronics* Item Tracer**

Min. requirements: Windows 3.1, 386 CPU, 4 MByte RAM, 2 Mbyte HD space. Windows 95 compatible.
Price: £15.00. £12.00 for subscribers (please quote your subscription number when ordering).
Order code: 956014-1.

***Elektor Electronics* slipcase**



Price: £2.95 + P&P (£1.50 UK; £2.00 outside UK)

Article title	Order no.	Price (£)	(US$)
- display PCB	920075-1	4.70	9.40
- front panel foil	930033-F	17.00	34.00
APRIL 1993			
Audio power meter	930018	10.25	20.50
Video digitizer for PCs:			
- PCB + disk (1831)	930007-C ●	37.00	74.00
- Software on IBM PC disk	1831	14.50	29.00
Infrared receiver for 80C32 single-board computer:			
- PCB and disk (1791)	920149-C	14.50	29.00
- software on IBM PC disk, also for DTMF decoder	1791	7.50	15.00
4MB printer buffer card:			
- PCB	920009	27.50	55.00
- EPROM 27C64	6041	15.30	30.60
- front panel foil	920009-F	8.25	16.50
MARCH 1993			
Linear sound pressure meter	930006	7.00	14.00
Electrically isolated RS232 interface	920138	10.25	20.50
TV test pattern generator for 8032 SBC			
- EPROM 27256	6151	15.30	30.60
FEBRUARY 1993			
Digital audio/visual system (4):			
- software package, EPROM, GALs and IBM PC disk	6181	30.50	61.00
U2400B NiCd battery charger:			
- PCB	920098	8.75	17.50
- front panel foil	920098-F	8.75	17.50
Digital-audio enhancer	920169	14.25	28.50
I²C opto/relay card:			
- PCB	930004	11.00	22.00
- software on IBM PC disk	1821	7.65	15.30
Watt-hour meter:			
- PCBs -1 and -2, and EPROM (6241)	920148-C	37.25	74.50
- EPROM 27256	6241	10.00	20.00
JANUARY 1993			
PAL test pattern generator:			
- PCB + GAL (6211)	920129-C	15.30	30.60
- GAL 20V8	6211	9.40	18.80
Multi-core cable tester			
- matrix board	926079	17.05	34.10
- slave unit	926084	6.20	12.40
- master unit	926085	8.25	16.50
DECEMBER 1992			
Digital audio/visual system:			
- PCB + EPROM (6171)	920022-C	34.10	68.20
- EPROM 27C256	6171	10.30	20.60
- panel foil dissolve unit	920022-F1	10.00	20.00
- panel foil remote control	920022-F2	19.40	38.80
- panel foil main unit	920022-F3	28.80	57.60
1.2 GHz multifunction frequency meter:			
- PCB + EPROM (6141)	920095-C	29.40	58.80
- EPROM 27C256	6141	11.45	22.90
- front panel foil	920095-F	13.80	27.60
Output amplifier for ribbon loudspeakers	920135-1	19.40	38.80
	920135-2	7.95	15.90
Peak-delta NiCd charger	920147	4.10	8.20
IDC-to-boxheader adaptor	924049	6.45	12.90
Mini keyboard for Z80	924047	12.35	24.70
80C552 µP system	924071	20.00	40.00
Mains power-on delay	924055	6.45	12.90
Speech/sound memory:			
- software on IBM PC disk	1771	7.65	15.30
NOVEMBER 1992			
Printer sharing unit	920011	14.70	29.40
Difference thermometer	920078	5.30	10.60
Low-power TTL-to-RS232 interface	920127	3.55	7.10
OCTOBER 1992			
Audio DAC - 3:			
- PCB	920063-3	26.45	52.90
- front panel foil	920063-F	10.00	20.00
Mains sequencer	920013	17.35	34.70
Wideband active antenna	924101	3.25	6.50
RDS demodulator	880209 ●	5.30	10.60
Pascal routines for Multi-function Measurement Card for PCs: software on disk	1751	9.70	19.40
SEPTEMBER 1992			
EPROM emulator - II			
- PCB	910082	10.00	20.00
- software on IBM PC disk	129	6.75	13.50
Audio DAC - 2	920063-2	18.80	37.60
JULY 1992			
12VDC to 240VAC inverter			
- main board	920039-1	11.15	22.30
- power board	920039-2	6.45	12.90
- front panel foil	920038-F	16.15	32.30
Audio DAC - 1	920063-1	8.50	17.00
Optocard for universal PC I/O bus	910040 ●	12.95	25.90
FM tuner - 5:			
- keyboard/display board	920005-4	14.40	28.80
- S-meter board	920005-6	3.80	7.60
- EPROM 27C256	6101	15.30	30.60
- front panel foil	920005-F	13.20	26.40
RS232 quick tester	920037	5.00	10.00
Water pump control for solar power system	924007	7.35	14.70
Simple power supply	924024	5.00	10.00
Wideband active telescopic antenna	924102	3.25	6.50
JUNE 1992			
I²C display	920004	4.70	9.40
FM tuner - 4:			
- mode control board	920005-3	5.60	11.20
- synthesizer board	920005-5	10.85	21.70
Guitar tuner:			
- PCB	920033	10.00	20.00
- front panel foil	920033-F	8.80	17.60
Multi-purpose Z80 card	920002	20.25	40.50
- GAL set (2x16V8)	6111	11.15	22.30
- BIOS EPROM 27128	6121	15.30	30.60
- software on IBM PC disk	1711	7.65	15.30
4MB printer buffer:			
- front panel foil	910110-F ●	11.45	22.90
- EPROM 27C64	6041	15.30	30.60
May 1992			
Compact mains supply	920021	7.35	14.70
FM tuner - 3 (PSU)	920005-2	8.80	17.60
GAL programmer:			
- PCB	920030	11.15	22.30
- software: see June 1993			
NICAM decoder:			
- PCB	920035	15.00	30.00
- front panel foil	920035-F	8.25	16.50
APRIL 1992			
80C32 SBC extension	910109	13.50	27.00
2-metre FM receiver	910134	10.30	20.60
Comb generator	920003	8.50	17.00
AD232 converter:			
- PCB	920010	12.35	24.70
- software on IBM PC disk	1691	7.65	15.30
Automatic NiCd charger	UPBS-1	2.30	4.60
LCD for L-C meter	920018	4.70	9.40
Milli-ohm meter adaptor	920020	4.40	8.80
MARCH 1992			
L-C Meter:			
- front panel foil	920012-F	11.45	22.90
8751 emulator	920019	12.05	24.10
- EPROM 27C64 + IBM disk	6051	29.40	58.80
A-D/D-A and I/O for I²C bus:			
- PCB	910131-2	6.15	12.30
- software on IBM PC disk	1821	7.65	15.30
AF drive indicator	920016	5.60	11.20
Centronics line booster	910133 ●	5.90	11.80
FM tuner (tuner board)	920005	21.15	42.30
MIDI optical link	920014	6.15	12.30
FEBRUARY 1992			
Audio/video switching unit	910130 ●	11.75	23.50
I²C interface for PCs	910131-1	14.40	28.80
Mini square wave generator	910151	5.30	10.60
Switch-mode power supply	920001	4.40	8.80
8051/8032 assembler course:			
- EMON51 EPROM + course disk for IBM PCs (1661)	6061	20.00	40.00
- EMON51 EPROM + course disk for Atari (1681)	6091	20.00	40.00
- course disk for IBM PCs	1661	7.65	15.30
- course disk for Atari	1681	7.65	15.30
JANUARY 1992			
Build your own CD player:			
- PCB	910146 ●	8.25	16.50
- front panel foil	910146-F ●	12.05	24.10
Fast precise thermometer	910081 ●	8.50	17.00
Low-frequency counter			
- input board	910149-1 ●	5.00	10.00
- display board	910149-2 ●	6.45	12.90
Mini Z80 system	910060	10.60	21.20
Prototyping board for IBM PCs	910049	21.15	42.30
PC-controlled weather station (3):			
- software on IBM PC disk (supersedes 1551 and 1561)	1641	7.65	15.30
DECEMBER 1991			
Class-A power amplifier (2):			
- protection PCB	880092-3	7.50	15.00
- power supply PCB	880092-4	7.60	15.20
µP programmable filters	910125	6.75	13.50
Amiga mouse/joystick switch:			
- PCB	914078 ●	4.10	8.20
- GAL 16V8	6001	8.25	16.50
Safe solid-state relay	914008 ●	3.80	7.60
Slave mains on/off control Mark-2	914072 ●	6.45	12.90
Connect-4 software in 2764 EPROM	6081	15.30	30.60
NOVEMBER 1991			
Relay card for universal I/O interface	910038 ●	12.95	25.90
Dissipation limiter	910071 ●	4.40	8.80
Class-A power amplifier (1):			
- voltage amp. PCB	880092-1	9.95	19.90
- current amp. PCB	880092-2	9.05	18.10
Timer for CH systems	UPBS-2	3.80	7.60
24-bit full-colour video digitizer (extension for Archimedes project):			
- software on Arch. disk	1631	11.15	22.30
OCTOBER 1991			
PC-controlled weather station (2)	900124-2 ●	3.80	7.60
Audio spectrum shift encoder/decoder	910105 ●	10.35	20.70
SEPTEMBER 1991			
Timecode interface for slide control:			
- main board	910055	24.40	48.80
- display board	87291-9a	4.10	8.20
- software on IBM PC disk	1611	7.65	15.30
- front panel foil	910055-F	8.80	17.60
Asymm-symm converter	910072	5.60	11.20
Plotter driver:			
- software on IBM PC disk	1541	11.15	22.30
JULY/AUGUST 1991			
Multifunction I/O for PCs:			
-PCB	910029	24.40	48.80
- PAL 16L8	5991	8.25	16.50
B/W video digitizer:			
- PCB	910053 ●	22.60	45.20
- software on Arch. disk	1591	11.15	22.30
Logic analyser - 5:			
- IBM PC disk + LA-GAL	1491	19.40	38.80
- Atari disk + LA-GAL	1501	19.40	38.80
Stepper motor board - 2:			
- power driver board	910054-2	28.50	57.00
LED voltmeter	914005 ●	5.60	11.20
Wien bridge	914007 ●	4.10	8.20
Angled bus extension card for PCs	914030 ●	12.05	24.10
Sync separator	914077 ●	4.40	8.80
JUNE 1991			
Universal battery charger	900134	9.40	18.80
Logic analyser - 4:			
- power supply board	900094-7 ●	8.80	17.60
- Atari interface board	900094-6 ●	12.65	25.30
- IBM interface board	900094-1 ●	14.40	28.80
- PAL 16L8 for IBM i/face	5971	8.25	16.50
Digital phase meter (set of 3 PCBs)	910045-1/2/3 ●	26.15	52.30
Light transceiver	UPBS-1	2.30	4.60
Variable AC PSU:			
- PCB	900104 ●	6.15	12.30
- front panel foil	900104-F	16.45	32.90
Light switch with TV IR r/c	910048	5.60	11.20
Real-time clock for Atari ST:			
- PCB	910006	6.15	12.30
- software on IBM PC disk	1621	7.65	15.30
Stepper motor board -1:			
- PAL 16L8	6011	8.25	16.50
MAY 1991			
80C32/8052 Computer	910042	12.05	24.10
Battery tester	906056	4.10	8.20
Universal I/O interface for IBM PCs	910046	10.85	21.70
APRIL 1991			
Logic analyser (3):			
- control board	900094-5 ●	18.50	37.00
MIDI programme changer:			
- PCB	900138 ●	6.75	13.50
- EPROM 2764	5961	15.30	30.60
8-bit I/O for Atari:			
- PCB	910005	12.35	24.70
- software on Atari disk	1571	7.65	15.30
6-m band transverter	910010 ●	11.45	22.90
Wattmeter:			
- meter board	910011-1 ●	6.45	12.90
- display board	910011-2 ●	4.10	8.20
Tektronix/Intel file converter:			
- software on IBM PC disk	1581	7.65	15.30
Dimmer for halogen lights:			
- transmitter board	910032-1 ●	4.10	8.20
- receiver board	910032-2 ●	4.40	8.80
MARCH 1991			
The complete preamplifier:			
- input board	890169-1	26.10	52.20
- main board	890169-2	39.35	78.70
FEBRUARY 1991			
Logic analyser (2):			
- Probe board	900094-3 ●	5.00	10.00
Multifunction measurement card for PCs:			
- PCB	900124-1	28.20	56.40
- PAL 16L8	561	10.30	20.60
- software on IBM PC disk	1461	7.65	15.30
MIDI-to-CV interface:			
- 2764 EPROM	5981	15.30	30.60
RDS decoder:			
- demodulator board	880209 ●	5.30	10.60
- processor board	900060 ●	7.65	15.30
- EPROM 2764	5951	15.30	30.60
JANUARY 1991			
Logic analyser (1):			
- Busboard	900094-4 ●	10.60	21.20
DECEMBER 1990			
Active mini subwoofer	900122-2 ●	6.15	12.30
Milliohmmeter	910004 ●	5.90	11.80
Phase check for audio systems	900114-1/2 ●	9.40	18.80
Signal suppressor for all-solid state preamp	904024 ●	4.40	8.80
NOVEMBER 1990			
Medium-power audio amplifier	900098	10.60	21.20
Programmer for the 8751			
- PCB	900100	8.25	16.50
- µC 87C51	7061	46.40	92.80
- software on IBM PC disk	1471	7.65	15.30
OCTOBER 1990			
µP-controlled telephone exchange:			
- PCB	900081 ●	21.15	42.30
- EPROM 27128	5941	15.30	30.60
SEPTEMBER 1990			
Infra-red remote control	904085/86	7.95	15.90
JULY/AUGUST 1990			
Compact 10A power supply	900045 ●	13.50	27.00
Intermediate projects	UPBS-1	2.30	4.60
Mini FM transmitter*	896118	5.00	10.00
Sound demodulator for satellite TV receivers	900057 ●	4.40	8.80
Audio power indicator	904004 ●	4.40	8.80
Four-monitor driver for PCs	904067 ●	6.15	12.30

* can not be supplied to readers in the UK

Article title	Order no.	Price (£)	(US$)
JUNE 1990			
Power zener diode	UPBS-1	2.30	4.60
MAY 1990			
Acoustic temperature monitor	UPBS-1	2.30	4.60
APRIL 1990			
Digital model train (13)	87291-10	4.70	9.40
Q meter	900031 ●	7.05	14.10
RS-232 splitter	900017-1	8.50	17.00
	900017-2	5.30	10.60
MARCH 1990			
Digital model train (12)	87291-9	4.10	8.20
Video mixer (3):			
- PCB	87304-3 ●	41.70	83.40
- EPROM 27128	5921	15.30	30.60
FEBRUARY 1990			
Digital Model Train (11)	87291-8	5.30	10.60
Reflex MW AM receiver	UPBS-1	2.30	4.60
JANUARY 1990			
Video mixer (1)	87304-1	32.00	64.00
Mini EPROM programmer	890164 ●	8.25	16.50
All solid-state preamplifier	890170-2*	18.50	37.00
The Digital Model train (10):			
- control program on disk	109	6.75	13.50

*The four PCBs required for the preamplifier (2 × 890170-1; 1× 890170-2 and 1× 890170-3) are available as a package, ref. 890170-9, at a discounted price of £48.15 (US$96.30). Front panel 890170-F is no longer available.

Article title	Order no.	Price (£)	(US$)
DECEMBER 1989			
Digital Model Train	87291-7	10.30	20.60
Solid-state preamp	890170-1*	13.80	27.60
	890170-3*	10.60	21.20
NOVEMBER 1989			
Digital Model Train (8)			
- PCB	87291-5	51.10	102.20
- EPROM 27C64	572	11.75	23.50
SEPTEMBER 1989			
Digital Model Train	87291-6	7.85	15.70
Resonance meter	886071	4.60	9.20
JULY/AUGUST 1989			
Function generator	UPBS-1	2.30	4.60
MAY 1989			
Digital Model Train (4)	87291-4	6.15	12.30
DTMF system decoder	890060	7.65	15.30
Sine-wave converter	UPBS-1	2.30	4.60
APRIL 1989			
Digital Model Train	87291-2/3	5.05	10.10
Function generator	UPBS-1	2.30	4.60
Multi-point IR control	890019-1	4.05	8.10
	890019-2	4.75	9.50
FEBRUARY 1989			
Digital Model Train	87291-1	4.95	9.90
VHF receiver	886127	8.75	17.50
JANUARY 1989			
Fax interface for Atari ST and Archimedes	880109	8.65	17.30
Low-budget capacitance meter	UPBS-1	2.30	4.60
DECEMBER 1988			
LFA-150 — a fast power amplifier	880092-3 ●	7.50	15.00
	880092-4 ●	7.60	15.20
CVBS-to-TTL adaptor	880098 ●	5.70	11.40
Autonomous I/O controller	880184 ●	18.00	36.00
NOVEMBER 1988			
Bus interface for hi-res LCD screens	880074 ●	19.70	39.40
LFA-150 — a fast power amplifier	880092-1 ●	9.95	19.90
	880092-2 ●	9.20	18.40
OCTOBER 1988			
Peripheral modules for BASIC computer	880159 ●	5.90	11.80
JULY/AUGUST 1988			
Frequency read-out for SW receivers	880039 ●	21.60	43.20
NOVEMBER 1987			
BASIC computer	87192	23.80	47.60

FOCUS ON: SCOPE MULTIMETERS

A new type of test instrument, the portable digital storage oscilloscope (DSO) has appeared on the electronics scene, and looks here to stay. This instrument is often combined with a digital multimeter (DMM), and is marked by a large LCD screen and a control panel which make it particularly suitable for field use. Prices of these units are beginning to come down to a level where even the hobbyist may become interested.

By our editorial staff

IN the field of measurement technology, microprocessors and automated measurements play an increasingly important role, and have a great effect on the working tools available to the electronics engineer and the service technician. Work that used to consist of just a few voltmeter checks now involves complex voltage waveforms and sequences, all of which have to be recorded and processed. Today's service engineer should be conversant with programmable controls, while he or she struggles with noise in switch-mode power supplies and faults in digital circuits based on extremely complex digital circuits. No wonder a test instrument for all these different functions is a must for cost-effective design, repair and adjustment work.

Manufacturers of electronic test instruments keep a close watch on such trends because of the market potential, which is another way of saying that they want to increase their turnover. Test instruments get smaller and smaller, more powerful, more intelligent, and ... cheaper! Currently prices have dropped to a level where even the advanced hobbyist may consider purchasing a portable DSO/DMM for use inside and outside the workshop.

The handheld oscilloscope has a large liquid crystal display (LCD) instead of a cathode ray tube (CRT). This change has made the instrument much lighter and smaller, which has obvious advantages for servicing and other field work. The portable DSO also doubles as a versatile digital multimeter, while even more functions are available that replace a pretty hefty stack of measurement equipment: frequency and event counter, logic analyser and function generator.

This article aims at presenting a couple of the more affordable portable DSOs/DMMs on the market today. The range of instruments is fairly small, and mainly supplied by Tektronix/Sony, Fluke/Philips, Escort and Hung Chang. The latter two are Korean manufacturers whose products are sold under the brand names Keithley and Gould respectively. Unfortunately Hitachi's product overview of portable oscilloscopes arrived too late for inclusion in this article.

Just like the modern oscilloscope seems to move into the direction of the digital multimeter, the multimeter is becoming an increasingly graphics-oriented instrument. You probably know the bargraph readout, which is far better than a sequence of just digital values when it comes to indicating slowly changing quantities ('trends'). New, however, are DMMs which are capable of showing a (simple) graph on an LCD screen. Unfortunately we found only two instruments, a Fluke and a Tektronix, which offered this relatively new feature. These instruments are available at a price below approximately £600.

Some impressions

Tektronix THS-710

This oscilloscope offers a DSO and a DMM function, but lacks a number of features available on competitive products. Fortunately, this has a positive effect on the quality of the measurements as well as on the ease of operation. Achieving a bandwidth of 60 MHz and a maximum sample rate of 250 MS/s the

THS-710 is the fastest of the DSOs/DMMs discussed in this article. All function keys and function areas are neatly arranged, and easily mastered by the new owner in a couple of minutes without the need of consulting the handbook. Multiple key functions are avoided wherever possible. Unfortunately, the THS-710 responds fairly slowly to key actions, a problem which is shared by all handheld DSOs. The 150-page manual supplied with the THS-710 is well laid out. Moreover, a quick reference is available.

The THS-710 has a brighter display than any of its competitors. In fact, the brightness is almost equal to that of a CRT. Of great interest are the instruments's extensive trigger options including TV, pulse width, and missing pulse.

The multimeter mode allows direct and alternating voltage, as well as resistance, to be measured. The multimeter values may be displayed as maximum, minimum or delta-max-min. Moreover, they may be averaged and held. An acoustic continuity tester, a diode check and a data logger function are also available. For reliable and safe measurements, the inputs of the instrument are electrically isolated from one another. The RS232 serial interface enables measured values, screendumps and other data to be conveyed to a PC. Supported file formats include TIF, BMP, EPS and HPGL. Optionally, the RS232 interface enables software to be uploaded and downloaded.

Other instruments:
THS-720, functionally similar, bandwidth 100 MHz.

Fluke: 96 ScopeMeter
As regards its price and technical data, the Fluke 96 ScopeMeter falls into the same class as the THS-710. The instrument is marked by extensive options for calculation and display, both in oscilloscope and multimeter mode. The maximum sensitivity is not achieved over the entire timebase range. The instrument has a very useful switchable function called Auto Set, which performs fully automatic settings for the timebase, trigger and attenuator.

The operation of the 96 ScopeMeter is a little more complex than that of the Tektronix instrument. Understandable, however, because of the more extensive measurement and display options. When the instrument is only used occasionally, you will find that the extensive, 180-odd pages thick manual has to be consulted to be able to perform measurements which call for the less usual functions. For 'emergency cases' a Quick Operating Card may be found in the carrying bag.

in addition to the oscilloscope function, the 96 Scopemeter has a 32/3 digit multimeter which not only measures direct voltages, alternating voltages and

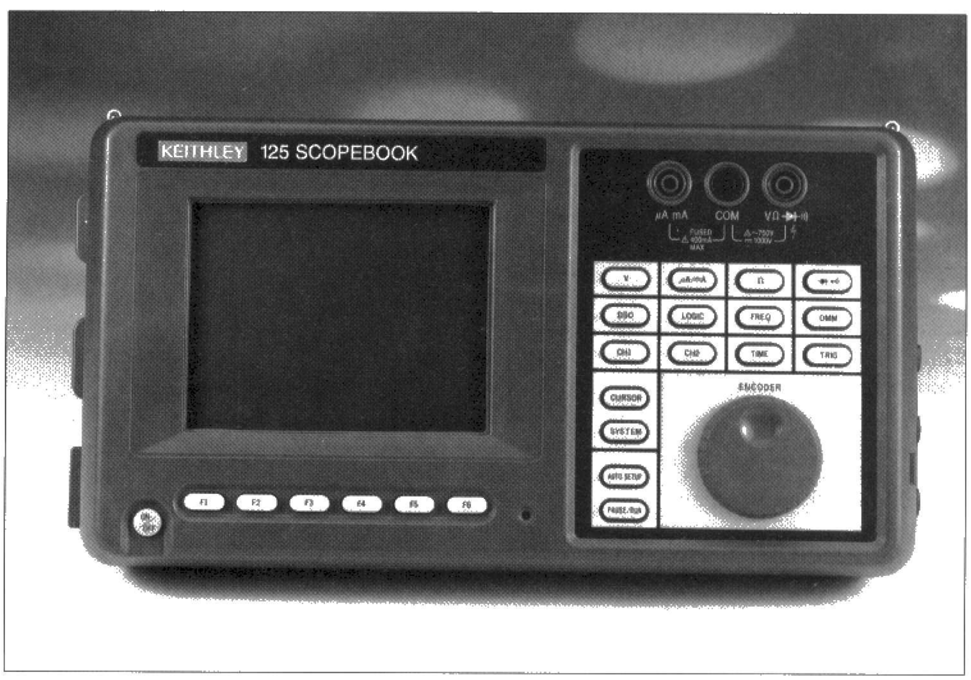
resistance, but also frequency, events, mark/space ratios and pulse widths. The measurement values may be displayed in different decibel notations. Also available are a diode tester, a continuity tester and a general-purpose component tester.

The 96 ScopeMeter has a an internal signal generator which supplies a rectangular test signal for adjusting probes. Instrument settings and signals may be memorized and sent to a PC or a printer via an optical RS232 interface. Software is available as an option.

A weak point of the instrument is its difficult to read LC display. In a practical test, our design engineers found that the display was only readable from a short distance, and vertically, when fluorescent lighting was used. The LCD's backlight failed to improve the readability. Somewhat better results were obtained under daylight conditions. The LCD has rather too much information on it, and the texts and symbols shown are poorly laid out. Also, in DMM mode the displayed figures are relatively small. On the positive side, a short help text may be called up for each item on the display. The 96 ScopeMeter is marked by low current consumption and a small number of sockets and plugs, which remain limited to an optical interface, a socket for the mains adaptor, two wander ('banana') sockets and two BNC sockets.

Other instruments:
Scopemeter 91, single-channel without cursor measurement function and memory;
Scopemeter 92, dual-channel without cursor measurement function and memory;
ScopeMeter 99, with signal shape mathematics, signal generator, component tester, full PC interface;
Scopemeter 105, as Scopemeter 99, however 100 MHz bandwidth.

Keithley: Model 125 ScopeBook (Gould EasyScope 340)
As far as could be ascertained, these are identical instruments manufactured by Korea-based Escort Instruments, who are known for their instruments with a good price/performance ratio. Not surprisingly, the Model 125 ScopeBook is much cheaper than the Tektronix or Fluke instruments. The ScopeBook not only offers DSO and DMM functions, it also doubles as an 8-channel logic



analyser and a frequency meter.

Unfortunately, the wealth of functions offered by the ScopeBook seems to be obtained at the cost of operating speed of the oscilloscope: a bandwidth of just 20 MHz may not be enough for modern measurement applications. None the less, the features of the oscilloscope meet the usual standards as regards horizontal and vertical deflection, as well as the triggering facilities.

The multimeter has a 33/4-digit display and a 40-segment bargraph readout. A diode and an acoustic continuity tester are integrated. Moreover, current measurement are possible without the need of connecting an extra probe, as with the Fluke and Tektronix instruments.

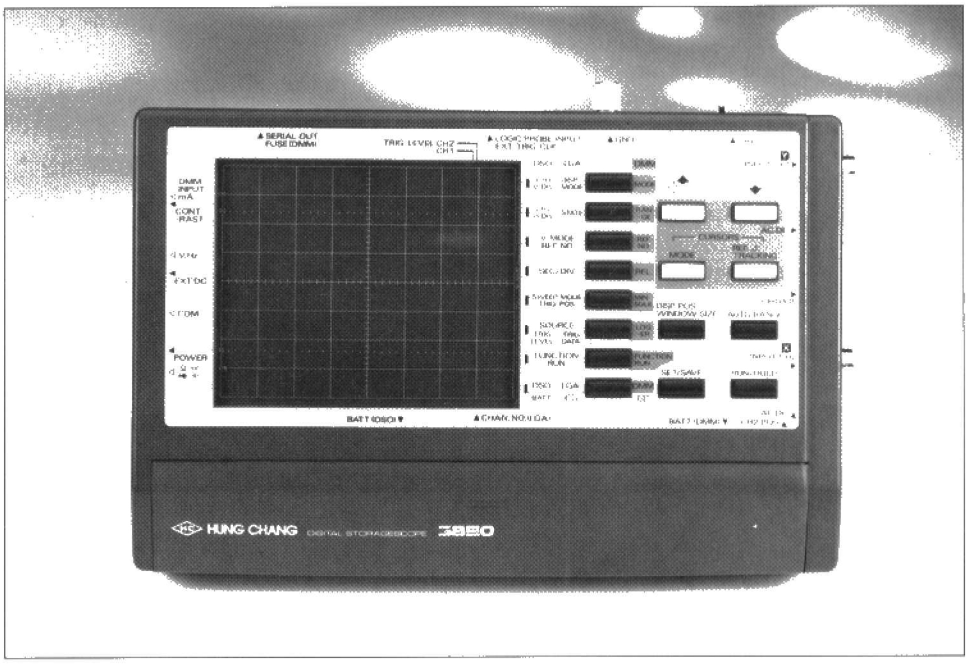
The 8-channel logic analyser turns the 125 ScopeBook into a multi-purpose test instrument. However, the timing resolution is on the low side, so that this interesting function is really only suitable for use with relatively slow signals.

The instrument has an 'encoder' rotary control on the front panel. This control replaces up/down buttons, and offers a simple and easy-going 'quasi-analogue' way of controlling the instrument. Without occasional recourse to the users manual, however, it is not always clear which functions are controlled by the rotary control, and which functions, by the rubber presskeys (having a an agreeable tactile 'click'). The display is sufficiently large and its readability is good even at bad lighting conditions and unfavourable viewing angles. As on the Fluke DSO, plastic BNC sockets are used. However, the ones on the ScopeBook appear to be made from a much harder plastic, and give a more solid impression. The documentation that came with the ScopeBook did not state the current consumption. The instrument put to our disposal for this article worked about 1.5 hours on a freshly loaded set of batteries.

Hung Chang: HC 3850 (DataBlue 6000)

These two instruments are identical and marketed under different brand names by Korea-based manufactures Hung Chang. Their price is much lower than that of the other three DSOs mentioned above, making it dangerous to do a direct comparison as regards technical data. None the less, the HC 3850 has the largest number of functions of all DSOs. Apart from an optically isolated DSO and DMM with voltage, current and resistance measurement, the instrument offers a frequency meter and a capacitance meter. A logic analyser with 16 channels is also integrated.

In most measurement modes, fewer ranges are available than on the other models. However, the measurement errors remain in the acceptable range. The bandwidth is stated as 50 MHz, while the maximum sample rate is an astounding 50 MS/s (on one channel).



The push buttons are a bit unstable, while the abbreviations used as function legends are not always clear until you have consulted the manual. The main shortcoming of the Hung Chang is, however, its display. Offering only low resolution, it gives a fairly 'coarse' impression. The low resolution not only

affects the graphs, it also makes the texts on the display difficult to read. Because of the limited space for them, texts are often abbreviated or turned into acronyms. Another obvious shortcoming, particularly with the graphics functions (DSO and logic analyser), is the lack of a clear distinction between measurement readout and text.

The graticule does not appear on the display as with the other instruments. Instead, it is printed at the inside of the cover plate. The printed graticule not only aggravates the parallax effect, it also interferes with the numerical display of the measured values.

The supply for the DSO and DMM sections are separated. While the six NiCd batteries for the DSO are exhausted after about 2.5 hours, the two cells for the DMM last about 200 hours. The Hung Chang has all-metal BNC sockets.

In spite of its shortcomings, the HC 3850 (DataBlue 6000) is an interesting choice for tight budgets, because it meets most requirements of the advanced electronics hobbyist.

Other instruments:
DataBlue 4000/HC3820 with 20 MHz bandwidth.

DMMs with graphics display

Apart from the above mentioned portable DSOs, we also had a chance to examine two graphic multimeters, the Fluke 863 and the Tektronix THM 420.

These two instruments look like normal, high-end DMMs. They are operated by a centrally located rotary switch, and feature autoranging. Autoranging, obviously, helps to keep the lettering around the rotary switch to a minimum. In addition to the rotary control, these graphic multimeters (GMMs) have a couple of extra buttons. On the THM 420, these buttons serve to select between two functions, creating a great resemblance with an ordinary DMM. The scope function only serves as a coarse indication of the graph shape — it is not really suitable for quantitative measurements because of the small height of the display, the low resolution and the poor scaling. The multimeter functions are limited to the bare essentials. An interface is not available on the Tek. On the positive side, the 863 is the only instrument which actually deserves the description *handheld*.

At the cost of being difficult to handle with just average size hands, the Fluke GMM offers a multitude of functions which may be selected and configured with the aid of six toggle keys and five so-called soft keys, each of which having different functions depending on the menu. Operation is relatively complex, so that you are really helpless without the manual. The measurement values have a very small basic error, while the graphics in 'view' mode are sufficiently large for an accurate indication of the graph shape. Here, too, the graticule could be clearer.

The Fluke 863 takes an intermediate position between a DMM and an oscilloscope. As shown in the photograph, the instrument allows a special mode to be selected which combines a numerical and a graphical display. The Fluke 863 does not have an interface, however this is available on more expensive GMMs in the series (which also offer additional features such as a memory for measured values). The protective, non-removable, case of the Fluke is of excellent quality.

Other instruments:
Fluke 865, with logic/component tester and signal memory;
Fluke 867, with logic/components tester, signal memory and PC interface.

The choice: handheld DSO, GMM or bench instrument?

If you are involved in any kind of field testing, calibration or repair work, the question whether or not to include the relatively new handheld DSOs and GMMs in one's choice is definitely answered in the positive. There can be no doubt that these new instruments are lighter and more compact than an equivalent stack of bulky, mains-powered bench instruments. Not so in the electronics laboratory, however, where benchtop instruments still have a better price/performance ratio, and better accuracy, than any of the new handheld DSOs and GMMs. Another totally different situation is that of the hobbyist, who may not be after the highest specs as regards accuracy. He or she may be perfectly satisfied with the performance of, for example, the Hung Chang instrument, which eliminates the usual cable mess when using separate instruments, and allows quick and efficient construction of prototypes. Provided the DSO supports the function, all measured data may be sent to a PC via a single interface for further processing. However, the cost of such an instrument will continue to be the decisive factor for the hobbyist. As already mentioned, handheld scopes are nice, but expensive. (950083)

Some useful addresses:
Write or telephone the manufacturers or their local sales offices for extensive technical data on their products.

Tektronix U.K. Limited, Fourth Avenue, Globe Park, Marlow, Bucks SL7 1YD. Tel. (01628) 403300. Fax: (01628) 403301.
Head office: Tektronix Inc., Corporate Offices, 26600 SW Parkway, P.O. Box 1000, Wilsonville, Oregon 97070-1000. Tel. (503) 682-3411, (800) 426-2200.

Fluke UK Ltd., Colonial Way, Watford, Herts WD2 4TT. Tel. (01923) 240511. Fax: (01923) 225067.
Head office: John Fluke Mfg. Co. Inc., P.O. Box 9090, Everett, WA 98206, U.S.A. Tel. (206) 347-6100. Fax: (206) 356-5116.

Keithley Instruments, Ltd., The Minster, 58 Portman Road, Reading, Berks RG3 1EA. Tel. (01734) 575666. Fax (01734) 59649.
European Headquarters: Keithley Instruments GmbH, Landsberger Str. 65, D-822110, Germany. Tel. (+49) 89 849307-0. Fax (+49) 89 84930759.

Hung Chang Products Co., Ltd., 2nd/3rd Floor, Hongje-dong, Seodaemun-ku, Seoul, Korea. Tel. (02) 395-8610/19. Fax (02) 395-5381/84.

With over 14,000 products the new Maplin Catalogue is now bigger than ever

THE EIFFEL TOWER

Built in 1889 by Alexandre Gustave Eiffel, the Eiffel Tower is 984 feet high and gives an unrivalled view of the whole of Paris.

THE NEW MAPLIN CATALOGUE

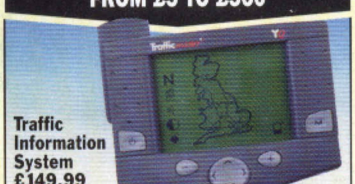
Built for 1996 by Maplin, the new catalogue is almost 1,200 pages long and gives an unrivalled view of the whole world of electronics.

Now Only £2.95

Home TV Security System £149.99

WIDE RANGE OF SECURITY PRODUCTS FROM £5 TO £400

LATEST NAVIGATION SYSTEMS FROM £5 TO £560

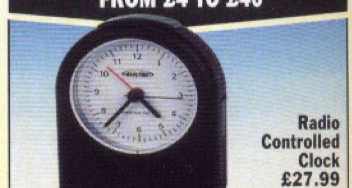


Traffic Information System £149.99

Universal Charger with Discharger £22.99

FULL RANGE OF CHARGERS FROM £6 TO £23

RANGE OF CLOCKS AND WATCHES FROM £4 TO £40



Radio Controlled Clock £27.99

JUST LOOK AT THESE SUPERB EXAMPLES!

Digital Multimeter with TTL Logic Tester £49.99

EXCEPTIONAL RANGE OF TEST EQUIPMENT FROM £3 TO £1300

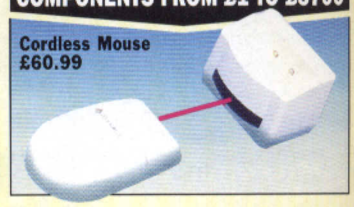
OVER 300 KITS FOR YOU TO BUILD FROM £5 TO £599

Millennium 4-20 Valve Amplifier Kit £199.99

EXTENSIVE RANGES OF COMPONENTS FROM MICROSWITCHES TO MICROPROCESSORS

OVER 100 PAGES OF COMPUTER COMPONENTS FROM £1 TO £3700

Cordless Mouse £60.99



MAPLIN ELECTRONICS AND BEYOND

Get your copy now from WHSMITH, John Menzies and Maplin stores nationwide

Or order direct NOW on 01702 554161

Catalogue Mail order Price £3.45 (inc p&p). Prices refer to the 1996 Maplin Catalogue and are inclusive of VAT. All items are subject to availability. E&OE. Maplin Electronics, P. O. Box 3, Rayleigh, Essex, England SS6 8LR.